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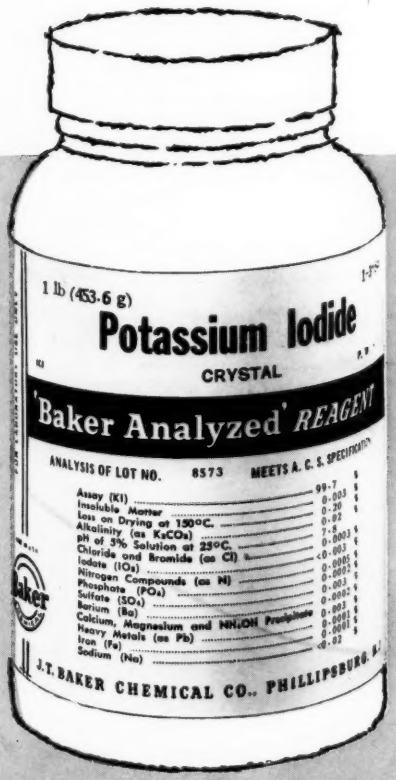
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VOLUME 32

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JOURNAL OF

CHEMICAL EDUCATION

The Introduction to Thermodynamics, *Duncan MacRae* 172

A Nonradioactive Demonstration of the Isotopic Exponential Exchange Law, *Milton Kahn* 177

Textbook Errors, *Karol J. Mysels* 179

Some Chemical Apparatus of Ancient Mesopotamia, *Martin Levey* 180

Using the History of Chemistry in Our Teaching, *Bernard Jaffe* 183

Models of Plane Molecules, *Bryant Harrell* and *Alsoph H. Corwin* 186

Karl Freiherr von Reichenbach, *Moritz Kohn* 188

This Cult of Brevity, *John H. Wilson, Jr.* 190

Inhibition of Carbonic Anhydrase by Thiocyanate, *Robert L. McGeachin* 191

Recent Research on Thyroid Hormone, *Norman Kharasch* 192

A Survey of Short Courses in Organic Chemistry, *Bernard Nelson* 195

Counseling the Woman Chemistry Major, *Ethaline Cortelyou* 196

A Periodic Chart Based on *s p d f* Electron Distribution, *Lewis E. Miller* 199

The Fluid Duplicator, *G. Ross Robertson* 200

Linear Polymers and Statistics, *Malcolm Dole* 202

General Education and General Chemistry, *Leslie S. Forster* 206

A Simple Gas-mixer Pump, *W. T. M. Johnson* 208

A Laboratory Exercise in Catalytic Dehydrogenation, *Elizabeth Allison, Richard Gorsich,* and *L. O. Binder* 209

Nice Timing 210

The Eastern Colleges Science Conference, *Donald D. Wright* 211

Proceedings of the Pacific Southwest Association of Chemistry Teachers Meeting of the Northern Section 212

Report of the New England Association of Chemistry Teachers Official Business 214

Device to Prevent Back-suction in Vacuum Systems, *G. P. Mathur* and *S. Mukherjee* 216

Editor's Outlook 171

Out of the Editor's Basket 47

Letters to the Editor 216

Recent Books 218

Frontispiece—Karl Freiherr von Reichenbach 23

Advertisers' Index 59

Tested Demonstrations in General Chemistry 19, 20

Annual Spring Book List 27–39

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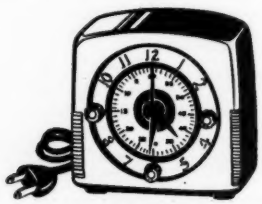

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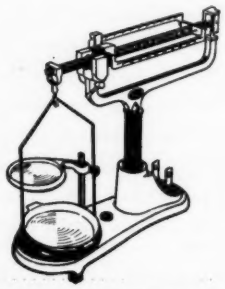

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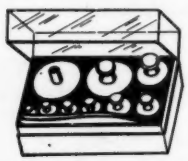

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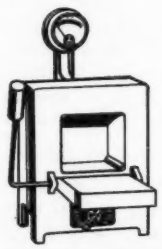

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4. WATER, ACIDS, BASES, SALTS†

A. WATER

Composition of water

4-1 *By weight.* Hydrogen-generator of mossy Zn + dil. HCl leading through 12 mm. tubing 30 cms. long to a U-tube containing $CaCl_2$. Porcelain boat containing CuO in tubing. Wing-tip burner under boat. **Explain, without carrying out Dumas' determination of the composition of water by weight from [wt. CuO − wt. Cu] = wt. 0; and [gain in weight of $CaCl_2$ due to H_2O] − wt. 0 = wt. hydrogen.**

4-2 *By volume.* Electrolysis of water, see 1-4.

Physical Properties of Water

4-3 *Purification by distillation.* $KMnO_4$, distillation apparatus, 400 ml. beaker. **Distill $KMnO_4$-aq., obtaining colorless distillate.**

*4-4 *Purification by adsorption.* 1-liter cylinder of muddy water, NH_4OH, $AlCl_3$-aq., large stirring rod. **Stir in 25 ml. $AlCl_3$-aq. Then add with stirring 25 ml. NH_4OH. Allow $Al(OH)_3$ to settle, carrying mud with it.**

*4-5 *Poor conductor.* Lump of ice, 25 g. weight, burner, test tube $^2/_3$rds. full of water over burner. Brass weight holding piece of ice to bottom of tube. **Boil upper portion of water.**

*4-6 *Aqueous tension.* Hg barometer made by inverting a 10 mm. glass tube, 100 cms. long, full of Hg in a 10 cm. crystallizing dish of Hg. Hot water, dropper with tip curved like fish-hook, towel, adhesive tape. Mark Hg level with tape. **Introduce a few drops of water and Hg level falls due to pressure of water vapor; mark with another tape. Apply towel soaked in hot water to barometer near water level and Hg level drops further due to increased P_{H_2O}.**

4-7 *Deliquescence.* Inverted U-tube, ends stoppered, one leg half-filled with water, other leg half-filled with crystals of $MgCl_2$. Mark level of water with a strip of adhesive tape, and write date on the tape. **Hang device where class can follow the progress of deliquescence during the term. The $MgCl_2$ deliquesces, removing water from the other arm.**

[Chemical Reactions of Water

4-8 *Efflorescence [and Deliquescence].* Five watch glasses, washing soda crystals, NaOH, Glaubers salt ($Na_2SO_4 \cdot 10H_2O$), blue vitriol ($CuSO_4 \cdot 5H_2O$), $K_2Cr_2O_7$. **Expose to air overnight.**

4-9 Pulverized blue vitriol, test tube and holder, burner, filter paper, anhydrous $CuSO_4$, wash bottle, anhydrous $CuSO_4$ in desiccator over $CaCl_2$. **Heat blue vitriol, showing turns white. Spread anhydrous $CuSO_4$ on paper and squirt water on it. Explain desiccator contents.**

*4-10 *Heat of reaction.* Very dry quicklime in 400 ml. beaker, wash bottle. **CARE: Show steam from slaking of lime (H_2O + CaO).**

4-11 50 ml. conc. H_2SO_4 in 200 ml. beaker, ether in a 0.5 ml. bulb blown at the end of a 6 mm. tube 30 cms. long, wash bottle, matches. **Pour 50 ml. water upon H_2SO_4. Stir with ether bulb and (CARE: Do not get ether on hands) light ether which boils off.**

B. ACIDS

*4-12 *With metals.* Mg ribbon, granular Zn, Cu turnings; dilute HCl, H_2SO_4 and HOAc; 12 test tubes. **Show H_2 generated, test for pop with lighted match. Show Cu inert.**

4-13 *Litmus.* Six 400 ml. beakers of water in a row, 6 strips 1″ wide litmus paper fastened to glass rod in a line, NH_4OH, NaOH-aq., $Ca(OH)_2$-aq., dilute HCl, H_2SO_4, and HOAc. **Dip papers simultaneously into six beakers of solutions showing 3 turn pink, 3 turn blue. Rotate rod and dip papers again, and colors reverse.**

Turn the page for additional demonstrations

* Footnotes

4-4 Illuminate the cylinder brightly from below.

4-5 Take care to keep burner flame from overheating that part of the test tube where there is no water, otherwise tube may crack.

4-6 Emphasize that the few drops of liquid water could not possibly weigh enough to depress the mercury column appreciably. Instead of a towel, a water jacket can be arranged around the upper level of mercury, and hot water poured into the jacket.

4-10 Danger, keep eyes away. The quicklime should be in large dry lumps, not powder. Fill beaker half-full of them, add $^1/_4$ beaker of water.

4-12 Danger. Keep face away from mouth of tube when acid is added to Mg ribbon.

4-16 This is an unusual experiment and needs to be explained to the student. The addition of acid changes the 1 N Na_2SO_3 (pH above 9.6) to 1 N $NaHSO_3$ (pH 4.3) and finally to 1 N H_2SO_3 (pH near 2). The indicators phenolphthalein, litmus, and brom cresol green turn at pH's 9.6, 7.0, and 4.3 as the acid is added.

Labels for Topic 4. (For code, see instructions for assembling kits, J. Chem. Educ., **32**, 12A(1955).) 4-1-*w*-mossy zinc, 4-1-*N*-HCl aq., 4-1-*J*-$CaCl_2$, 4-1-*w*-CuO, 4-3-*d*-$KMnO_4$, 4-4-*N*-muddy water, 4-4-*N*-NH_4OH, 4-4-*N*-$AlCl_3$ aq., 4-6-*N*-Hg, 4-6-*d* with curved tip-water, 4-7-*w*-$MgCl_2$. 4-8-*w*-$NaHCO_3$, 4-8-*w*-NaOH, 4-8-*w*-Glaubers salt, $Na_2SO_4 \cdot 10H_2O$, 4-8-*w*-$CuSO_4 \cdot 5H_2O$, 4-8-*w*-$K_2Cr_2O_7$, 4-9-*w*-pulverized $CuSO_4 \cdot 5H_2O$, 4-9-*w*-anhydrous $CuSO_4$, 4 labels marked 4-10-*w*-quicklime, CaO (tightly stopper each bottle), 4-11-*N*-ether, 4-12-*w*-Mg ribbon, 4-12-*w*-granular Zn, 4-12-*w*-Cu turnings, 4-12-*N*-HCl aq., 4-12-*N*-H_2SO_4 aq., 4-12-*N*-HOAc aq., 4-13-*d*-NH_4OH, 4-13-*d*-NaOH aq., 4-13-*d*-$Ca(OH)_2$ aq., 4-13-*d*-HCl aq., 4-13-*d*-H_2SO_4 aq., 4-13-*d*-HOAc aq., 4-14-*d*-phenolphthalein soln., 4-14-*d*-methyl orange soln., 4-14-*d*-methyl violet soln., 4-14-*d*-litmus soln., 4-14-*d*-NaOH aq., 4-14-*d*-HCl aq. 4-15-*d*-methyl violet soln., 4-15-*d*-Bogen indicator soln., 4-15-*N*-0.1 normal HOAc, 4-15-*N*-0.01 normal HOAc, 4-15-*N*-0.001 normal HOAc, 4-15-*N*-1 normal Na_2CO_3, 4-15-*N*-1 M H_3BO_3, 4-15-*N*-HCl aq., 4-16-*d*-phenolphthalein soln., 4-16-*d*-brom cresol green soln., 4-16-*N*-freshly prepared 1 normal Na_2SO_3, 4-16-*N*-1 normal H_2SO_4, 4-17-N- 0.1 normal NaOH, 4-17-*d*-phenolphthalein soln., 4-17-*N*-H_2SO_4, about 0.2 normal, 4-18-*w*-NaCl, 4-18-*d*-phenolphthalein soln., 4-18-*N*-KI aq., 4-20-*N*-NaOH aq., the following ions possibly as chlorides: 4-20-*d*-Fe^{++}, 4-20-*d*-Fe^{+++}, 4-20-*d*-Cu^{++}, 4-20-*d*-Co^{++}, 4-20-*d*-Ni^{++}, 4-20-*d*-Zn^{++}, 4-20-*d*-Al^{+++}.

† By Hubert N. Alyea, Frick Chemical Laboratory, Princeton, New Jersey. April, 1955

4-14 *Other indicators.* Four U-tubes clamped in stand and containing water plus a few drops of indicator, each different; solutions of phenolphthalein, methyl orange, methyl violet and litmus, NaOH-aq., HCl-aq. **Few drops acid in one limb, hydroxide in other showing different colors.**

4-15 *Different pH's.* Methyl violet, Bogen indicator, 0.1, .01, and .001N HOAc, 1N Na_2CO_3, 1M H_3BO_3, HCl-aq., 12 test tubes. **Show different pH's give different colors.**

*4-16 Litmus paper, phenolphthalein solution, brom cresol green solution, 20 ml. pipette, 1N Na_2SO_3, 50 ml. burette filled with 1N H_2SO_4, 200 ml. beaker, stirring rod. **Few drops phenolphthalein in 25 ml. Na_2SO_3 in beaker; color red. Run in H_2SO_4 from burette; turns colorless at pH 9.6. Dip in litmus paper; is blue. Continue adding H_2SO_4 to pH 7; litmus paper turns pink. Add few drops brom cresol green; color green. Continue adding H_2SO_4 to pH 4.3; indicator turns yellow.**

4-17 *Acid-base titration.* 0.1N NaOH in 25 ml. burette, 10 ml. pipette, 600 ml. beaker, filter paper, phenolphthalein solution. About 0.2N H_2SO_4. **Titrate 10 ml. of H_2SO_4 containing a few drops of phenolphthalein + 500 ml. water by running in NaOH. Discuss calculations.**

C. HYDROXIDES

4-18 *Formation by electrolysis.* U-tube containing 10 g. NaCl + few drops phenolphthalein solution + 10 ml. of KI-aq. in 100 ml. water; electrodes leading into solution and to 110 volts D.C. **Electrolyze: red at minus pole from NaOH, brown at positive pole from $Cl_2 + 2KI \rightarrow I_2$.**

4-19 *Varieties.* Sticks, pellets, flakes of NaOH and KOH, $Ca(OH)_2$, CaO, NH_4OH. Exhibit hydroxides. Recall 4-13.

4-20 *Solubilities of hydroxides.* NaOH-aq., dilute aq. solutions containing chlorides of Fe^{++}, Fe^{+++}, Cu^{++}, Co^{++}, Ni^{++}, Zn^{++}, Al^{+++}; 10 test tubes. **Show insoluble hydroxides. Note and explain re-dissolving of $Al(OH)_3$ and $Zn(OH)_2$ in excess of NaOH.**

Next month's Tested Demonstrations in General Chemistry

5. STATES OF MATTER. SOLUTIONS

For a complete list of topics for 1955–6 see J. Chem. Educ. 32, 28–9(1955).

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Karl Freiherr von Reichenbach

(See page 188)

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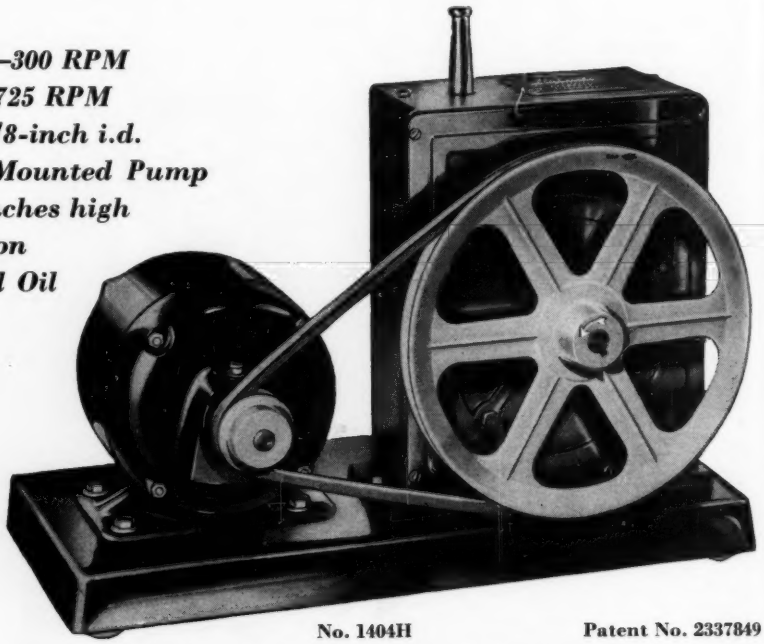

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Editor's Outlook

THE intangible returns to the professional teacher have not been better recounted than by Dr. Arthur Osol on the occasion of his award of the Honor Scroll of the Pennsylvania Chapter of the American Institute of Chemists last December.[1] Dr. Osol is head of the chemistry department of the Philadelphia College of Pharmacy and Science and has been a teacher all his life; so he knows what he is talking about.

The point he wants to make, and which I believe most teachers would support, is stated thus:

> While agreeing that scientists, and especially teachers, generally received inadequate financial remuneration for their services, I doubt very much that lack of financial reward is the basic reason for the shortage of teachers and scientists. It is unfortunate that there is a tendency in some quarters to hastily jump to this conclusion, and it is deplorable that there appears to be some trend toward evaluating all forms of human endeavor in terms of financial reward only. Such a basis of evaluation is not, and never can be, a common denominator for relating the merits of different professions, or of different areas of specialization within a profession, or of people themselves. I find it impossible to believe that the question of financial reward now motivates people so completely that little else matters when a job is to be selected.

Since it is perfectly obvious that the financial returns in the teaching professions are not as great as in other professions, then those who choose to go into this calling, or to stay in it when once in, must recognize other advantages. Dr. Osol lists some of these, of course the ones which seem most important to him.

Certainly, one of these is not the long summer vacations, for most teachers find themselves actually busier during this time than during the school year—often, to be sure, earning enough money to balance their budgets.

He thinks the first reward is the knowledge that the teacher is giving more than he receives. While this is not good business it can nevertheless be a motivating factor of great force. The part that a teacher can take in molding the careers of men and women and preparing them for lives of usefulness can satisfy the soul more than money in the bank.

The teacher has the opportunity of being a student all his life—indeed, he must if he is to maintain his effectiveness. Of course, teachers are not the only ones who should continue to learn throughout their lives, but involved in the formal activity of learning as they necessarily are, they must not only participate in it but *lead* it, or they drop behind and are lost. Teachers must be perpetual students; fortunately there are many to whom this opportunity appeals.

The teacher also has the opportunity, and largely the responsibility, to render service to the community. This is another "something-for-nothing" activity but nevertheless important enough for college administrations to consider in cases of academic promotion. It takes such forms as activity in one's professional organizations, service on public committees and commissions, and public lectures. While prominent men in any other fields also are expected to serve in these ways, still the teacher finds that such service is accepted as part of his implicit responsibility, and unless the demands are excessive he can take pride and pleasure in it.

Most teachers find that one of the greatest rewards of their profession is the opportunity to conduct unrestricted research. This is what is really meant by "academic freedom" and should be perhaps the most jealously guarded attribute of the profession. The right kind of teacher will accept this not merely as a reward but as a real responsibility. University administrations sometimes carry this to an extreme in the compulsions they exert on teachers to "produce or die."

A comforting thought is also expressed for those who really worry about making ends meet:

> Lest anyone receive the impression that the abundance of these non-monetary rewards is so great that the recipient is likely to finish his days in the poorhouse, I would emphasize that it would be surprising indeed if in the course of one's doing his dead-level best along these lines there will not have come opportunities for adequate financial reward as well. It has been my observation that teachers who have toiled assiduously through many years have not been without recognition by those who can utilize the teachers' services and pay them dollars, and I suspect that with increasing years of service the disparity of the financial reward of the teacher diminishes.

There will still be many who feel that the hard facts of economic life cannot be so easily overlooked. Every effort should of course be made to raise teachers' salaries to a level more nearly consistent with the importance of their services. But meanwhile let us not despair. Teachers who are attracted solely by salary are not likely to be effective or to remain long in the profession.

There is good reason to believe that the present shortage of scientists and of teachers is not primarily the result of poor salaries, but of the fact that at the time when they are choosing their careers young people are not adequately informed of the opportunities in science and teaching. If we really believe in our own profession we should be able to make its advantages sound attractive. Apparently we are not doing so. Why not?

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[1] "Teaching—chemistry's most rewarding opportunity," *The Chemist*, 32, 49 (February, 1955).

THE INTRODUCTION TO THERMODYNAMICS

II: Temperature as a Potential[1]

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One of the principal objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity.
—*J. Willard Gibbs*

CHEMICAL thermodynamics can be taught with greater ease and effect if, in introducing the subject, the teacher makes more use of the students' previously acquired knowledge. Chemical thermodynamics is principally a study of volume (pv), thermal (TS), and chemical ($\bar{G}N$) energies.[2] The beginner has already studied kinetic, gravitational, electric, magnetic, and surface energies.[3] There are certain points of similarity in all these kinds of energy. What, then, could be simpler than to begin the new course by bringing out the points in previous instruction that will be helpful in presenting the new?

If such a review begins with electric energy, it can be easily shown that there are, at least, ten simple and useful equations expressed in terms of the potential and quantity for that kind of energy. As the review extends to the other forms of energy, it will develop that these equations also apply to a great extent to the potentials and quantities for the other four forms of energy.

When these ten equations are later applied to volume, thermal, and chemical energy, it will be found that they contain criteria for reversibility and equilibrium, expressions for the heat (and therefore for the entropy) generated in irreversible processes, and for the rates of diffusion of chemical substances. They also contain definitions of energy and temperature, which are, for some purposes, superior to the usual analytical expressions of the first and second laws of thermodynamics.[4] These definitions of temperature have the advantage that this important variable is defined in the same way as other potentials. In terms of work, the definition is as follows: Difference in potential is equal to the work required to transfer an appropriate unit quantity from a place, state, or system at a potential to one at another; or

$$P_2 - P_1 = -W_r/\Delta k \qquad (1)$$

in which P_1 and P_2 are the potentials, $-W_r$ is the work required for the transfer of the quantity Δk. In terms of energy, the definition is an follows: If the energy of a system is considered as a function of its energetic quantities, the potential for one of these quantities is equal to the partial derivative of the energy with respect to that quantity; or

$$\partial E/\partial k = P \qquad (2)$$

In their application to gravitational work and energy, the variables and operations of these two definitions are so familiar to the student that he can see them with his mind's eye as he reads them. For the first definition, the transfer of a weight from one system to another is accomplished in three steps. First, a weight of Δk pounds is withdrawn from a system at a height of P_1 feet above sea level. Since there is no motion of the weight in the direction of the force of gravity, no work is required for this step. Next, the weight is lifted vertically to a height of P_2 feet above sea level. The work, $-W_r$, required for this step is $(P_2-P_1)\ \Delta k$. Finally, the weight is added to the system at the height P_2. No work is required for this step because there is no motion of the weight in the direction of the force of gravity. Thus, the total work required for the transfer is $(P_2-P_1)\ \Delta k$, and this divided by Δk is equal to P_2-P_1, as required by equation (1). For the second definition, Δk pounds of water at P feet above sea level flows slowly into the top layer of water in a very large reservoir at the same height. Its energy, just before it enters the reservoir, is $P\Delta k$ foot pounds. It carries this energy with it into the reservoir. So the increase in energy of the reservoir per pound of water added to it, $\Delta E/\Delta k$, is equal to $P\Delta k/\Delta k = P$. When the quantity of water added is very small compared with that in the top layer, $\Delta E/\Delta k = \partial E/\partial k$ and $\partial E/\partial k = P$, as equation (2) requires.

The application of these two equations to gravitational work and energy gives an idea of the kind of review of previous instruction that may be profitably undertaken. Instead of mere repetition of what has gone before, familiar facts can be presented from a different point of view so that the marked similarities in the various kinds of energy will be clearly seen and easily remembered. The students will thus be prepared to pass from the consideration of kinetic, gravitational, electric, magnetic, and surface energies to that of volume, thermal, and chemical energies with much the same ease as they passed from the study of the first five groups of elements to the next three in the periodic table.

[1] Based on a paper presented before the Division of Chemical Education at the 126th Meeting of the American Chemical Society, New York, September, 1954.

[2] See equation (21) below.

[3] Not to mention the energy of springs, vibrating bodies, electromagnetic radiation, and nuclear changes.

[4] For example, it is convenient to use a form of equation (2) to express energy as a function of composition, because the terms so introduced are strictly neither heat nor work and cannot be logically introduced by means of the first law of thermodynamics in its usual form. *Cf.* GIBBS, J. W., "Collected Works," Longmans, Green and Co., New York, 1931, Vol. I, pp. 63, 93.

Yet, no matter how necessary it may be to lighten teachers' burdens and to improve the students' comprehension of thermodynamic principles, there are things which deter teachers from defining temperature in the same way as other potentials. Commenting on a previous suggestion[5] that this be done, experienced teachers have said: First, that to do this means that temperature must be defined in terms of entropy, an intangible something that is very difficult to comprehend; second, that it is not clear that thermal potentials are the same thing as thermodynamic temperatures; third, that there may be difficulties in defining temperature in terms of a variable which is itself defined in terms of temperature; and fourth, that energy must be defined before equation (2) can be used to define a potential. Since these points were not discussed in the previous paper, further explanation seems to be required. These objections must be answered, because the definition of temperature as a potential is the keystone of the arch of the bridge between the study of gravitational, electric, and magnetic potentials and that of the chemical potentials.

In answering the first objection, it is admitted that entropy, as presented in many textbooks, is difficult for the beginner. But suppose that it were thought necessary to use the same sort of presentation in explaining what is meant by the weight of an object. It would first be necessary to invent a special name for gravitational energy, *e. g.*, "weat." Then a classical science of "gravitodynamics" must be found. Its primary purpose would be to permit calculations of the fraction of "weat" that could be converted into work. Its first law would state that the increase in the energy of a system is equal to the work done on the system plus the "weat" received from the surroundings. Its second law would state that it is impossible to construct a machine which is able to convey "weat" from one system to another, at a higher level than the first, unless work is done on the machine by an outside agency.[6] After these preliminaries, the differential of the weight of a body would be defined as equal to the inexact differential of the "weat," transferred reversibly from the surroundings to the system, divided by its height above sea level. It would then be proved that the differential of the weight, so defined, is exact. It would finally be stated that a better way to define weight depends on a principle like that of Caratheodory; but that it is too difficult to be understood by a beginner. These might be valid procedures and highly satisfying to the intellect and aesthetic sense of the teacher; but they do not represent the point of view from which the subject is most simple for a student who has just completed college physics.

But it is no more necessary to define entropy in this way than it is so to define weight. One hundred and thirty years ago Carnot said: "The motive power of a water fall depends on its height and on the quantity of liquid; the motive power of heat depends also on the quantity of caloric used, and on what may be termed, or what in fact we call, the height of its fall, that is to say the difference in temperature of the bodies between which the exchange is made." If we replace the word *caloric* by the word *entropy*,[7] this statement becomes a definition of entropy and temperature. Entropy may thus be imagined as present in, or a property of the hot gases of the fire box of a steam engine and flowing with the heat through the metal walls of the boiler into the water, converting it to steam. It then passes, in the steam, to the walls of the condenser. It there leaves the steam and passes, with the heat, through the metal walls of the condenser into the cooling water.

According to this definition, entropy differs from heat as the weight of water differs from the gravitational energy associated with it in its passage through a turbine. The weight of water Δk withdrawn from the reservoir at the height P_1 is delivered below unchanged; but the quantity of gravitational energy withdrawn is $P_1\Delta k$, while that discharged is the smaller quantity $P_2\Delta k$. So, also, is the heat discharged to the condenser smaller than that which entered the steam; while the entropy discharged to the condenser, like the weight of the water, is unchanged in amount.[8] The maximum work obtainable from either a heat engine or a water turbine is, if energy is to be conserved, equal to the difference between the energy withdrawn at the higher potential and that discharged at the lower, or $P_1\,\Delta k - P_2\,\Delta k$. This result is the same as that expressed in equation (1) above, except that there the relation is extended to six other kinds of energy.

For the student who has just reviewed his previous instruction in the different kinds of energy, as suggested above, there is, perhaps, no more concise and complete definition of entropy and temperature than to say that they are the quantity and potential for thermal energy; for this implies to him all the relations given in equations (1) and (2) above, and (11) to (20) below. He should be warned, however, that confusion often results from failure to remember that entropy has two different aspects. It is a *quantity* which can be transferred without change from one system to another by reversible processes. It is also a *property of a system* which is determined by its state and, in statistical mechanics, is related to probability and disorder. Whether it be quantity or property, the unit of entropy may be defined simply as equal to the increase in entropy of a mixture of ice and water when a specified weight of ice in it melts.

Finally, even if the notion of entropy is still obscure, the advantages of defining thermodynamic temperature in terms of entropy are believed greatly to exceed its disadvantages.

In answering the second objection, it is first recalled that the equation

$$T_2 - T_1 = -W_r/\Delta S_1 \qquad (3)$$

may be derived from the following equations:

[5] MacRae, Duncan, J. Chem. Educ., **23**, 366–74 (1946).

[6] There may be doubt as to the generality of this statement; but it is true in the sense that water will not flow uphill by itself.

[7] La Mer, V. K., *Am. J. Phys.* **22**, 20–27 (1954); **23**,(in press).

[8] This is strictly true only for the reversible, or quasistatic operation of a heat engine; but that is the kind of operation that must be assumed in calculating the maximum work obtainable.

$$\Delta E = Q_1 + Q_2 - W_r \quad (4)$$

$$Q_1 = T_1 \Delta S_1 \quad (5)$$

$$Q_2 = T_2 \Delta S_2 \quad (6)$$

$$\Delta S = \Delta S_1 + \Delta S_2 \quad (7)$$

in which ΔE and ΔS are both equal to zero because they are the increase in energy and entropy, respectively, of a substance which has passed through a Carnot cycle and returned to its initial state; and ΔS_1 and ΔS_2 are the increases in entropy of the substance when it receives the quantities of heat Q_1 and Q_2 from reservoirs at the temperatures T_1 and T_2 respectively. From this derivation it follows that the temperatures T_1 and T_2 in equation (3) are the same as those in the second law equations (5) and (6), and are, therefore, thermodynamic temperatures. Equation (3) may be used to define any number of thermodynamic scales by assigning different values to its constants, ΔS_1 and T_1; but if Δk in equation (1) be put equal to ΔS_1, and P_1 to T_1, a comparison of the result with equation (3) will show that P_2 must be equal to T_2. Consequently, under these conditions the temperature of a system must be equal to its thermal potential.

In answering the third objection, it is admitted that, at first sight, it seems to be objectionable to define temperature in terms of a variable which is itself defined in terms of temperature. If, however, what is meant is to combine equations (3) and (5) above so as to eliminate ΔS_1, the result

$$W_r = Q_1(T_1 - T_2)/T_1 \quad (8)$$

has been generally accepted for a number of years. Derived in this way, this equation is based on the definition of temperature as a potential and can be used to define and measure thermodynamic temperature. It does not, however, bring out as clearly as might be desired the fact that temperature may be defined in the same way as other potentials, and it does seem to have the fault to which objection was made.

On the other hand, it is quite possible to begin, as suggested above, by defining entropy and temperature as the quantity and potential for thermal work; and then to define their units independently, beginning with entropy. For example, the unit of entropy can be defined as increase in entropy of one gram of ice when it melts at its triple point. This unit might well be called the carnot.[9] The unit of temperature can now be given any value whatsoever, quite independently, by assigning an appropriate numerical value to the temperature at the triple point. This could be 100, making the unit 1/100 of the difference in temperature between the absolute zero and the triple point.[10] This unit might well be called the giauque. The corresponding unit of work would be the carnot-giauque. It might also be called the bronsted,[11] just as the unit of electrical work, the volt-coulomb, is often called the joule. These units are not proposed to replace the units of entropy, temperature, and work now in general use; but solely to help make it clear that thermodynamic temperature scales can be based on units of entropy whose definitions are independent of any specific temperature scale.

When temperature is thus defined as a potential, it may be measured, in principle at least, with an electrically operated heat pump.[12] For example, if a highly efficient heat pump is connected to an ice calorimeter as a source and a system of unknown temperature as a sink, and is then operated until exactly 3.4286 grams of ice

[9] *Cf.* CALLENDAR, H. L., *Proc. Phys. Soc.* (*London*), **23**, 173 (1911).

[10] This is in accord with the suggestion of W. F. Giauque that thermodynamic temperature scales be based on the absolute zero and one other fixed point; see KLOTZ, IRVING M., "Chemical Thermodynamics," Prentice-Hall, **1950**, p. 105.

[11] This seems appropriate in view of Brönsted's suggestion of a uniform treatment of the various kinds of work, including thermal work. See BRÖNSTED, J. N., *Phil. Mag.*, **29**, 449–70 (1940).

[12] More properly called an entropy pump, because, as shown in equations (5), (6), and (7) above, ΔS_2 is equal to $-\Delta S_1$, but Q_2 is not equal to $-Q_1$.

TABLE 1

Force, Work, and Energy in the Transport of Energetic Quantities from One System to Another

Kind of energy	*Force, f*	*Work, $-W_r$*	*Energy, E*
Kinetic	$\Delta m\, \ddot{s}$	$\Delta m\,(\dot{s}_2^2/2 - \dot{s}_1^2/2)$	$m\,\dot{s}^2/2$
Gravitational	$-\Delta m\, m'F/s^2$	$\Delta m\,(m'F/s_2 - m'F/s_1)$	$m\,(m'F/s)$
	Δw	$\Delta w\,(h_2 - h_1)$	$w\,h$
Electric	$\Delta e\, e'B/s^2$	$\Delta e\,(e'B/s_1 - e'B/s_2)$	$e\,(-e'B/s)$
Magnetic	$\Delta n\, n'C/s^2$	$\Delta n\,(n'C/s_1 - n'C/s_2)$	$n\,(-n'C/s)$
Volume	$(p_1 - p_2)\,A$	$\Delta v\,(p_1 - p_2)$	$v\,(-p)$
Surface	$(\gamma_2 - \gamma_1)\,l$	$\Delta\sigma\,(\gamma_2 - \gamma_1)$	$\sigma\,\gamma$
Chemical	pA	$\Delta N\,RT \ln (p_2/p_1)$	$N\,RT \ln p$
Thermal	[a]	$\Delta S\,(T_2 - T_1)$	$S\,T$

[a] Work derived from Carnot cycle.

Symbols

A	area	e	electric charge
B	constant	f	force
C	constant	h	height above sea level
E	energy	l	length on which surface tension acts
F	constant		
N	number of moles	m	mass
R	gas constant	p	pressure
S	entropy	s	distance
T	temperature	$\dot{s}$	velocity
W_r	reversible work	$\ddot{s}$	acceleration
γ	surface tension	v	volume
σ	surface	w	weight
		n	number of unit magnetic poles

The operator, Δ, means "the increase in." For example, when mass is transported from one system to another, Δm denotes the increase in mass of the second system. It is also equal to the decrease in mass of the first system, and, therefore, to the quantity of mass transported from one system to the other.

The following relations were used in integrating *fds*: $\ddot{s}ds = \dot{s}d\dot{s}$; $Ads = dv$; $lds = d\sigma$; and $pv = NRT$.

are formed, the temperature which is desired will be equal to the electrical work in calories plus 273.16.

In reply to the fourth objection, it is recalled that, even in high school, energy was defined as capacity to do work. In the second or third year at a university the student will recognize this definition in the form:

$$-\Delta E = W_r \text{ or } \Delta E = -W_r \qquad (10)$$

The third column of Table 1 gives, for eight kinds of energy, expressions for the work required to transfer an energetic quantity Δk from one system, or state, to another. By equation (10), these expressions are equal to the corresponding increases in energy. The last column is derived from the third by considering the case in which the energy of the initial state is zero. The subscripts are then no longer necessary, because there is only one term. The delta is also dropped to show that the quantity is considered as independent rather than the increment of another quantity. The results in the third column are obtained by integrating the product of the force, given in the second column, and the displacement ds. With these expressions for the work and energy, the potentials for each kind of energy may be defined by either equation (1) or (2).

Once these potentials have been defined, calculations such as those for Table 1 are somewhat simplified. For the force is in each case $\Delta k(dP/ds)$, the element of work is $\Delta k dP$, the work is $\Delta k(P_2 - P_1)$, and the energy is kP, as shown in Table 2. Further, if we consider the energy of a system as a function of its mass, weight, electric charge, number of unit magnetic poles, surface, volume, entropy, and the number of moles of the various substances composing it, it follows from the definition of a total differential and equation (2) above that:

$$dE = \Psi dm + h dw + V de + \omega dn + \gamma d\sigma - p dv + \Sigma \bar{G}_i dN_i + T dS \qquad (11)$$

in which the symbols have the meanings given at the bottom of the tables. This equation shows eight different terms which may occur in an expression for the differential of the energy of a system; but it is seldom necessary to use so many in calculations relating to a real system. Often an equation containing only two or three of these terms is very valuable.

If it is now clear that entropy need not be so difficult to comprehend, that thermal potential and thermodynamic temperature are the same thing, that the unit of entropy may be defined without reference to any specific temperature scale, and that, even in thermodynamics, energy may be defined as capacity to do work, perhaps teachers will consider more favorably the suggestions of this and the previous paper for improving the introduction to thermodynamics.

An indication of what may be done in this direction will be found in Chapters 2 and 3 of Zemansky's "Heat and Thermodynamics."[13] Five kinds of energy, with which the student is already familiar, are discussed there and the element of work for each of them expressed

[13] ZEMANSKY, MARK W., "Heat and Thermodynamics," McGraw-Hill Book Co., Inc., New York, 1951.

TABLE 2

Force, Work, Energy, and Potentials in the Transport of Energetic Quantities from One System to Another

Kind of energy	*Force, f*	*Work, $-W_r$*	*Energy, E*
Kinetic	$\Delta m\, d\psi/ds$	$\Delta m(\psi_2 - \psi_1)$	$m\psi$
Gravitational	$\Delta m\, d\phi/ds$	$\Delta m(\phi_2 - \phi_1)$	$m\phi$
	Δw	$\Delta w(h_2 - h_1)$	wh
Electric	$\Delta e\, dV/ds$	$\Delta e(V_2 - V_1)$	eV
Magnetic	$\Delta n\, d\omega/ds$	$\Delta n(\omega_2 - \omega_1)$	$n\omega$
Surface	$\Delta\sigma\, d\gamma/ds$	$\Delta\sigma(\gamma_2 - \gamma_1)$	$\sigma\gamma$
Volume	$\Delta v(-dp/ds)$	$\Delta v(p_1 - p_2)$	$v(-p)$
Chemical	$\Delta N\, d\bar{G}/ds$	$\Delta N(\bar{G}_2 - \bar{G}_1)$	$N\bar{G}$
Thermal	$\Delta S\, dT/dS$	$\Delta S(T_2 - T_1)$	ST

Symbols not explained in Table 1

ψ kinetic potential
ϕ gravitational potential
ω magnetic potential
V electric potential
$\bar{G}$ chemical potential

in terms of "generalized forces" and "generalized displacements." As defined elsewhere,[14] these are nearly, if not quite the same as quantities and potentials. While names are not in themselves important, the latter designations suggest more readily the ten equations mentioned above as generally applicable to the eight kinds of work and energy listed in Table 1.

These equations are (1) and (2) above and the following:

$$\text{Field strength, } f/\Delta k = dP/ds \qquad (12)$$

$$\text{Force, } f = \Delta k(dP/ds) \qquad (13)$$

$$\text{Work, } f ds = \Delta k\, dP \qquad (14)$$

$$\text{Energy, } dE = \Sigma P dk \qquad (15)$$

$$\text{Heat generation, } Q' = \Sigma(P_1 - P_1)\Delta k \qquad (16)$$

$$\text{Criterion of reversibility of coupled processes, } \Sigma(P_2 - P_1)\Delta k = \qquad (17)$$

$$\text{Criterion of equilibrium in the absence of coupled basic processes, } P' = P'' = P''', \text{ etc.} \qquad (18)$$

$$\text{Rates of steady-state processes, } -dk/dt = (P_2 - P_1)/r \qquad (19)$$

in which r is a constant.

If Zemansky's text were revised to include some mention of the extent to which these ten equations apply to the five kinds of energy which he now discusses, and to kinetic and gravitational energy, it would constitute an even more serviceable review of the students' previous instruction in work and energy with little, if any more effort on the part of student and teacher than is now required for his Chapters 2 and 3.

Equation (1) not only serves to define potentials, but can be used to calculate the maximum work obtainable from Carnot's waterfall or flame, or the work required to remove a chemical substance from a solution. Equation (2) can be used to calculate the energy of a charged condenser, or as a convenient form of the second law of thermodynamics. Equation (12) puts the field strength equal to the potential gradient and is known to the students from their study of electricity in college physics. Equation (13) is obviously a rearrangement of equation (12). It can be used to calculate the force on an elec-

[14] SYNGE, J. L., AND B. A. GRIFFITH, "Principles of Mechanics," McGraw-Hill Book Co., Inc., New York, 1949, pp. 292–6.

tron in an electric field or the force on a small quantity of entropy in a temperature gradient. Equation (14) follows from equation (13) and the definition of work. On integration, it becomes equation (1). Equation (15) results from a combination of equation (2) with the definition of an exact, or total differential as a function of two or more variables. Expressed in the common symbols for potentials and quantities, it becomes equation (11) above. On integration for constant values of the potentials, that equation becomes:

$$E = m\dot{s}^2/2 + hw + Ve + \omega n + \sigma\gamma - pv + \Sigma\bar{G}_i N_i + TS \quad (20)$$

Equations (11), (15), and (20) are different forms of the equations for the total energy of a system. When E is equal to the first two terms on the right side of equation (20), it is the definition of the energy of a falling body in terms of its kinetic and (gravitational) potential energy. When E is equal to the last three terms, we have what is, perhaps, the most important equation of classical chemical thermodynamics:

$$E = TS - pv + G \quad (21)$$

in which $G = \Sigma\bar{G}_i N_i$. From this equation it is evident that the enthalpy of a system, $E+pv$, is the sum of its thermal and chemical energies; that the Helmholtz free energy $E-TS$ is the sum of the volume energy and the chemical energy; and that the Gibbs' free energy $E-TS+pv$ is the same as the chemical energy of the system.

Equation (16), with other symbols, was used by the students in high school to calculate the heat generated by an electric current. In the general form given here it is an expression of Brönsted's equivalence principle. In it, Q' has a somewhat different meaning from the Q of the usual analytical expression of the first law.[15] For Q there represents the heat received by the system from its surroundings, while Q' is the heat generated in an irreversible "basic energetic process." For example, if we consider a quantity of water and a platinum heating coil enclosed by a Dewar flask as our system, we may calculate Q', the heat generated by an electric current through the wire, and it may be considerable; but since no heat is transferred as such to the surroundings from the system, the Q of the first law would be zero for this operation. Equation (16) may be used to calculate the heat generated when any energetic quantity is transported irreversibly from one potential to another. An especially interesting case is the generation of heat by the flow of entropy from one temperature to another. At the temperature T the heat generated, Q', is equal to TS', and thus the flow of a quantity of entropy ΔS results in the generation of a quantity of entropy S'. Similarly, entropy is generated in any irreversible process, which is another way of saying, with Clausius, that "the entropy of the universe tends to a maximum."

Equation (17) is a combination of Brönsted's equations (1) and (3), and is a statement of his work principle.[16] The student would recognize it in the form of a statement that the increase in the kinetic energy of a falling object is equal to the decrease in its potential energy leaving its total energy unchanged.[17] In its application to an electric cell, it leads to the important equation

$$-\Delta G = \epsilon nF \quad (22)$$

in which $-\Delta G$ is equal to all the terms, $(P_2-P_1)\,\Delta k$, for chemical energy, and ϵnF, for electrical energy.

Equation (18) follows from equation (13). If the potential gradient is everywhere zero, the potentials throughout a homogeneous system are equal, the forces are all zero, and the system is at equilibrium. Gibbs[18] states this condition explicitly for temperature, pressure, and chemical potential, and uses it in discussing the equilibrium of heterogeneous substances. The restriction to the absence of coupled processes is from the rule of potentials of La Mer, Foss, and Reiss,[19] and is quite consistent with Gibbs' treatment of gravitational and electric potentials.[20]

Equation (18) is familiar to the student as Ohm's law and can be used in studying the rates of diffusion of chemical substances and other subjects treated in publications on the thermodynamics of the steady state.[21] While it would be expected to hold only when differences in potential are very small, it is valid over a considerable range for the flow of electricity or water.

The use of these equations, as suggested above, should do much to relate the subject of thermodynamics to other familiar subjects, so that it will "no longer stand as a thing apart; but, rather as [the] natural consequence[s] of long familiar ideas."[22] Their use may also save both teacher and students much valuable time.

ACKNOWLEDGMENT

In the preparation of this paper and the other cited above, the writer is greatly indebted to Professor Irving M. Klotz, of Northwestern University, and to Professor Duncan MacRae, Jr., of the University of California, for many pleasant and helpful discussions of the subject. In addition to this, the completion of this paper is largely due to the encouragement of Professor Victor K. La Mer, of Columbia University, who has used Brönsted's methods to obtain new results in thermodynamics and has called attention to the fact that Brönsted's approach (which gives a prominent place to equation (1) above) is both elegant and compact.

[15] La Mer, Victor K., Olav Foss, and Howard Reiss, *Ann. N. Y. Acad. Sci.*, **51**, 605 (1949); Brönsted, J. N., *Phil. Mag.*, **29**, 449–70 (1940); Steinour, Harold H., J. Chem. Educ., **25**, 15–20 (1948); Sandved, Karl, and Hans Holtan, Jr., J. Chem. Educ., **26**, 288 (1949).

[16] Brönsted, J. N., *loc. cit.*

[17] While this is not usually considered to be a reversible process, and Brönsted does not discuss kinetic energy in the references cited above, it is interesting to see that his criterion of reversible processes holds in this case.

[18] Gibbs, J. Willard, *loc. cit.*, Vol. I, page 65.

[19] La Mer, V. K., O. Foss, and H. Reiss, *loc. cit.*

[20] Gibbs, J. Willard, *loc. cit.*, Vol. I, pp. 145, 333.

[21] Denbigh, K. G., "The Thermodynamics of the Steady State," John Wiley & Sons, Inc., New York, **1951**; Holtan, Hans, Jr., *J. Chem. Phys.* **19**, 519–25 (1951).

[22] *Cf.* Lewis, G. N., and M. Randall, "Thermodynamics," McGraw-Hill Book Co., Inc., New York, **1923**, pp. 109–10.

A NONRADIOACTIVE DEMONSTRATION OF THE ISOTOPIC EXPONENTIAL EXCHANGE LAW

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THE equation

$$AX + BX^o = AX^o + BX \qquad (1)$$

represents a simple isotopic exchange reaction where the atom X is common to molecules AX and BX; X^o indicates a radioactive atom of X. Neglecting radioactive decay of X^o, the exponential exchange law for this reaction is[1]

$$-\ln (1 - F) = \frac{a + b}{ab} Rt \qquad (2)$$

where

F = fraction exchange;
a = concentration of X (active + inactive) in the form of AX (moles·liter^{-1});
b = concentration of X (active + inactive) in the form of BX (moles·liter^{-1});
t = time;
R = constant rate of exchange of X atoms between AX and BX (moles·liter^{-1}·time^{-1}).

In this paper an experiment is described whereby a student in the undergraduate physical-chemistry laboratory can demonstrate the operation of the exchange law without the use of radioactive isotopes. This experiment has the particular value of forcing the student to correlate observations on a system apparently far removed from isotopic exchange, with the ideas presented in the derivation and discussion of the exchange law as it pertains to radioactive exchange.

Consider the apparatus shown in Figure 1. The straight bore of stopcock D has been plugged so as to leave only a small volume v, in the bore at each end. Thus, by turning stopcock D through 180° a volume v of gas in section B is transferred to section A and a similar volume of gas is transferred from A to B. Initially, by proper manipulation of stopcocks F and C, the entire system is filled with air at some arbitrary pressure. Section B is isolated from A by turning stopcock F; A is then evacuated and subsequently isolated from the pump by manipulation of stopcock C. It is clear that continued rotation of stopcock D will result in a net transfer of air from B to A and that eventually the pressures in both sections will be equal.

If a given number, n, of 180° turns of stopcock D represents an interval of time t, then nv represents r, the rate of transfer of "volume" from B to A and from A to B. Provided v is very small compared to the volumes of A and B, the rate at which the pressure in A will increase with time is given by the following expression:

$$-\ln \left(1 - P_A \frac{V_A + V_B}{V_B P^o_B}\right) = \frac{V_A + V_B}{V_A V_B} rt \qquad (3)$$

where

V_A = volume of section A;
V_B = volume of section B;
P_A = pressure in section A at time t;
P^o_B = pressure in section B at time $t = 0$.

Equation (3), which is similar in form to equation (2), is derived below in a manner designed to show the analogy between the previously discussed experiment and isotopic exchange. The derivation is parallel with that given by Friedlander and Kennedy for the isotopic exchange law!

Imagine each section (A and B) to be composed of a large number of cells of volume ΔV. Each cell can accommodate one and only one molecule of gas. Cells differ only in that they may or may not contain a molecule of gas. In the chemical system the radioactive isotope is treated as chemically identical with the stable isotope. In the gas system a cell containing a molecule is equivalent to an empty cell with respect to transfer from one section to another. Moreover,

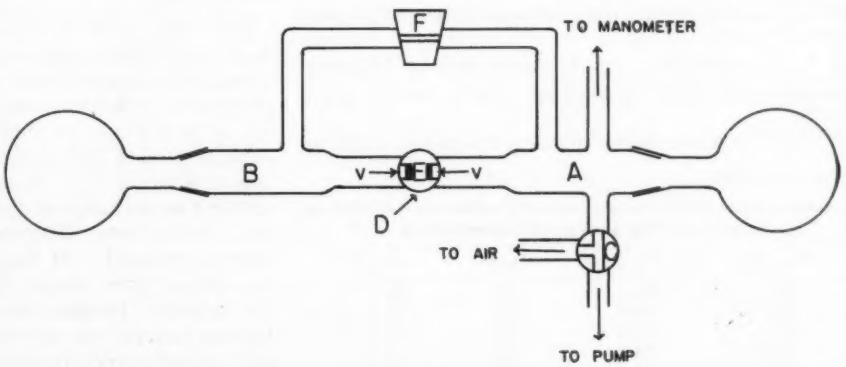

Figure 1. Gas-exchange Apparatus

C, three-way stopcock; *D*, 6-mm. straight-bore stopcock; *E*, plug; *F*, 2-mm. straight-bore stopcock.

[1] FRIEDLANDER, G., AND J. W. KENNEDY, "Introduction to Radiochemistry," John Wiley & Sons, Inc., New York, 1949, p. 285.

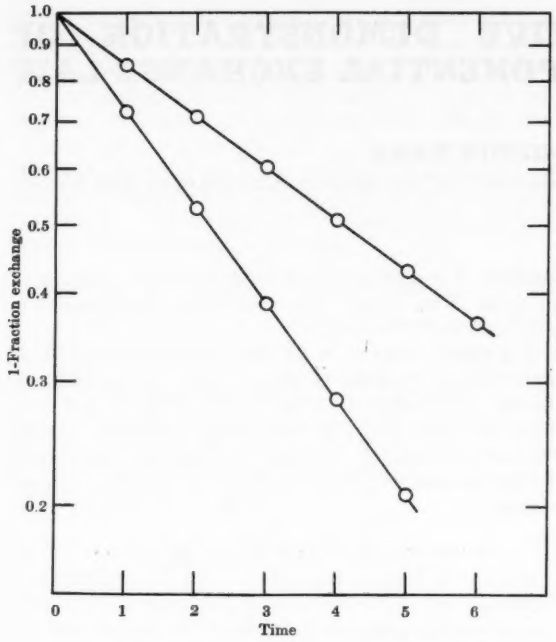

Figure 2. Two Typical Runs in the Gas-exchange System

Unit of time is 50 360° turns. Upper curve: V_A = 226 cc., V_B = 177 cc. Lower curve: V_A = 77.2 cc., V_B = 177 cc.

a cell which contains a molecule is a "marked" cell and corresponds to the radioactive isotope in the chemical system. The following symbols and expressions of Friedlander and Kennedy are redefined in terms of the gas system:

a = total number of cells in A;
b = total number of cells in B;
x = number of "marked" cells in A;
y = number of "marked" cells in B;
$z = x + y$ = total number of "marked" cells;
R = number of cells exchanged between A and B in unit time;
$\frac{y}{b}$ = fraction of cells in B which are "marked" and also the probability that a cell transferred from B to A is "marked";
$\frac{a-x}{a}$ = fraction of cells in A which are not "marked" and also the probability that a cell transferred from A to B is not "marked";
$\frac{y}{b}\cdot\frac{a-x}{a}$ = probability that in a given exchange of cells a "marked" cell in B is exchanged for a cell in A which is not "marked";
$\frac{Ry}{b}\frac{a-x}{a}$ = rate of transfer of "marked" cells from B to A at any given instant;

Results of Gas-exchange Experiments

P^o_B, mm.	V_A, cc.	V_B, cc.	r,cc./t*
637	226	177	18.1
631	95.6	177	17.9
427	95.6	177	17.9
264.5	95.6	177	17.8
639	77.2	177	18.2

* Unit of time equals 50 360° turns.

$\frac{x}{a}$ = fraction of cells in A which are "marked" and also the probability that a cell transferred from A to B is "marked";
$\frac{b-y}{b}$ = fraction of cells in B which are not "marked" and also the probability that a cell transferred from B to A is not "marked";
$\frac{x}{a}\cdot\frac{b-y}{b}$ = probability that in a given exchange of cells a "marked" cell in A is exchanged for a cell in B which is not "marked";
$\frac{Rx}{a}\cdot\frac{b-y}{b}$ = rate of transfer of "marked" cells from A to B at any given instant;
$\frac{dx}{dt}$ = rate of appearance of "marked" cells in A.

It follows that

$$\frac{dx}{dt} = \frac{Ry}{b}\frac{a-x}{a} - \frac{Rx}{a}\frac{b-y}{b} \qquad (4)$$

The solution of this first-order linear equation is:

$$x = Ce^{-\frac{a+b}{ab}Rt} + \frac{a}{a+b}z \qquad (5)$$

where C is a constant of integration. When $t = \infty$, $\frac{x_\infty}{a} = \frac{z}{a+b}$, or in words the ratio of "marked" cells in A to total number of cells in A equals the ratio of the "marked" cells in A and B to the total number of cells in A and B. Therefore, the second term on the right of equation (5) equals x_∞, the number of "marked" cells in A when the pressure in A equals the pressure in B. Also, when $t = 0$, $x = 0$ because initially A was evacuated, and consequently $C = -x_\infty$. From the foregoing discussion it follows that:

$$-\ln\left(1 - \frac{x}{x_\infty}\right) = \frac{a+b}{ab}Rt \qquad (6)$$

Equation (6) is identical with equation (2) where $F = \frac{x}{x_\infty}$. Equation (3) is obtained from equation (6) by considering that:

$a = V_A/\Delta V$, $b = V_B/\Delta V$, $R = r/\Delta V$, $x \sim P_A$, and $x_\infty \sim V_B P^o_B/V_A + V_B$

EXPERIMENTAL

The 6-mm. bore of stopcock D was plugged with a small, tight-fitting solid rubber cylinder. Apiezon wax Q was applied to both sides of the rubber plug with a hot glass rod in order to insure against leakage. In practice it is difficult to plug the stopcock so that the volumes at each end of the bore are the same; therefore, a rotation of D through 360° was considered as effecting an exchange of volume equal to the total volume in the bore. Stopcock D was lubricated with Apiezon grease L. It was found desirable to replace the grease after about 700 360° rotations because the stopcock became increasingly difficult to turn. The manometer was constructed of 2-mm. bore capillary tubing in order to minimize the slight change in the volume of A as the pressure in A increased. The volume of B was calculated from the weight of water re-

quired completely to fill B. The volume of A was then determined by simply allowing air at a known pressure in B to expand into A which had been previously evacuated, and noting the final pressure of air in the entire system. Some experimental results are summarized in the table. Typical plots of ln $(1 - F)$ versus t are shown in Figure 2. These plots are straight lines leading into the origin in accordance with equation (3). The results show that the rate of exchange r is independent of P^o_B, the initial pressure in B. Analogously, in the chemical system the rate of exchange R is independent of the amount of radioactivity present. The average value of r, 18.0 cc./t, obtained via the exchange experiments is in good agreement with the value 17.5 cc./t calculated from the total volume of the bore which was obtained by determining the weight of mercury required completely to fill the bore. It should be noted that, whereas in the gas system r is not a function of V_A or V_B, R in the chemical system will, in general, depend on a and b.

TEXTBOOK ERRORS[1]

I: The Mechanism of Vapor-pressure Lowering

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THE fact that the vapor pressure of the solvent is lower over a solution than over the pure solvent and that the lowering is proportional to the concentration, is frequently[2] explained as follows: A dynamic equilibrium exists in both cases, so that the rate at which molecules of solvent evaporate from the liquid is always equal to that at which they condense. The rate of condensation is proportional to the partial pressure of the vapor, while that of evaporation is unimpaired in the pure solvent but is impaired by solute molecules in the surface of the solution. Hence, the rate of escape is reduced in proportion to the concentration of the solute and maintenance of equilibrium requires a corresponding lowering of the rate of condensation and therefore of the partial pressure of the vapor phase.

There are at least four arguments showing the incorrectness of this explanation.

(1) The above reasoning implies that larger molecules which will obstruct the surface more effectively should cause a greater lowering of the vapor pressure when present in same numbers. This, of course, is contrary to Raoult's law.

(2) The explanation violates the principle of microscopic reversibility,[3] since it makes the molecules of solute obstruct the escape but not the arrival of the molecules of solvent.

(3) In fact, accumulation of molecules at the surface, such as is known to occur in solutions of surface-active agents, has no effect on the vapor-pressure lowering of these solutions, which is normal in very dilute solutions and very *low*, once micelles are formed.[4]

(4) An insoluble material, such as cetyl alcohol, which can have no significant effect on the equilibrium vapor pressure of water, can nevertheless reduce the rate of evaporation by a factor of 6000 as it forms a tightly packed monomolecular layer on the surface.[5] It must therefore reduce the rate of condensation in the same proportion.

[1] Suggestions of material suitable for this column are eagerly sought and will be acknowledged. They should be sent with as many details as possible to K. J. M. at the address indicated above.

[2] Since the purpose of this column is to prevent the spread and continuation of errors, and not the evaluation of individual texts, the source of the errors discussed will not be cited. The error must occur in at least two independent standard books to be presented.

[3] TOLMAN, R. C., "The Principles of Statistical Mechanics," Oxford University Press, 1938, p. 163.

[4] HUFF, H., J. W. MCBAIN, AND A. P. BRADY, *J. Phys. Chem.*, **55**, 311 (1951).

[5] LANGMUIR, I., AND V. J. SHAEFER, *J. Franklin Inst.*, **235**, No. 2 (1943); also in F. R. MOULTON, Ed., "Surface Chemistry," A. A. A. S. Monograph, 1943.

o o o

SOME CHEMICAL APPARATUS OF ANCIENT MESOPOTAMIA[1]

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ANCIENT chemical technology would be better understood if we had a knowledge of the equipment employed in the early Mesopotamian chemical industries. This paper will describe some of this apparatus in order to facilitate more accurate study of the chemical processes which were in use in those times. This ancient chemical apparatus will be compared, where necessary, with the much later and better known Alexandrian and Arabic equipment. Among the items to be discussed are vessels for liquids, apparatus for sublimation, distillation, and extraction, mortars and pestles, mills, strainers, filters, crucibles, drip bottles, and separatory apparatus.

Figure 1. Prehistoric Seal Impression of Two Workers Stirring in a Vessel

VESSEL TYPES

Among the types of vessel may be included containers for both storage and heating as well as those adapted from them for more specialized purposes such as extraction, sublimation, and distillation.

Early vessels in Mesopotamia were almost all of clay, while those of stone or wood were in use at the same time. Scores of names of different types of vessel have been noted in the tablet literature. Their exact construction or use has not as yet been determined owing to the numerous lexical unknowns in Sumerian and Akkadian. It is known, however, that tamarisk and *huluppu* woods were commonly used for the construction of containers and common utensils.

Very ancient vessels which were used for storage or in heating processes were often round-bottomed just as they were in later Greek and Arabic times. Representative pots are shown in Figures 1[2] and 2.[3]

The most important find in recent years for the history of chemical apparatus has been in the excavations at Tepe Gawra in northeast Mesopotamia, approximately fifteen miles from present-day Mosul, Iraq. Here vessels have been unearthed which show evidence of having been used in heating processes and could very well have been utilized for the specialized purposes of extraction, sublimation, and distillation. One type of pot has a large trough formed by its two brims. In its inner lip there are drainage holes leading back to the inside of the container. This design would be admirable for extraction of botanical or zoological materials.

A further development of this specialized type of apparatus is that shown in Figure 3.[4] This vessel strongly resembles, in its important details, apparatus used in Alexandrian and Arabic sublimation techniques. (See Figure 4.[5]) It would also have been useful in distillation of low-boiling substances such as some essential oils, and particularly so in the derivation of volatile substances such as perfumes. The vessel in Figure 3 was recently put together from its fragments by the author. It was found in Level XI of Tepe Gawra which would date it about 3500 B.C. It has a volume of 37.3 liters, whereas the channel in which a distillate or sublimate would be collected has a capacity of 2.1 liters. In actual practice only one-half to one-third of the vessel would be filled, so that the trough capacity would compare favorably with that of the volume of material used for sublimation or distillation. A large number of very short, horizontal scratch marks are visible in the channel

[1] Presented before the Division of History of Chemistry at the 126th Meeting of the American Chemical Society, New York, September, 1954.

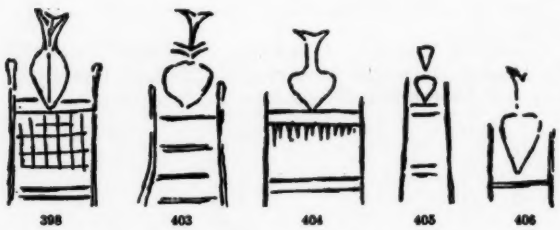

Figure 2. Drawings from Seals of Babylonian and Assyrian Furnaces

[2] Figures 1 and 6 and their descriptions are in TOBLER, A. J., "Excavations at Tepe Gawra," University of Pennsylvania, Philadelphia, 1950, Vol. 2.

[3] VON DER OSTEN, H. H., "Ancient Oriental Seals in the Collection of Mr. Edward T. Newell," Oriental Institute Publications XXII, Chicago, 1934.

[4] Figures 3 and 9 are from originals in the University Museum, University of Pennsylvania.

[5] BERTHELOT, M., "La Chimie au Moyen Âge," Vol. I, pp. 149–50, after MS Latin 6514 in the Bib. Nat.

of the vessel. These appear to have been made by a spatula or some thin scraping instrument.

The round-bottomed vessels were supported on shallow circular rings like those in use today. These objects of clay are to be found throughout the entire history of chemical technology. Where used in a manufacturing establishment the bases were plain, but when employed in ritual use or in a wealthy home, they were elaborately decorated.[6] Often the stand was pierced with a number of air holes, indicating that it was used both as a support and hearth for gentle-heating purposes.

The round-bottomed vessels may also have been suspended over the fire, as is evidenced by holes near the upper edge of a Tepe Gawra vessel.[7] Metal hooks would then be used to hold the pot over the fire.

MILLS AND MORTARS

The ancient mortar (^{a}NA)[8] and pestle (*amittu*) were fashioned in the form we know today. In Tepe Gawra some excellent examples have been found. For the grinding of ores and glass these are almost always made of stone.

Also made of stone were the mills which were manufactured for a specific duty. In the first millenium B.C. two principal types of mill were used—some worked by hand and others turned by beasts.[9] The common hand mill consisted simply of a round flat stone above another flat stone slightly larger in diameter.[10] The upper millstone[11] (*^{a}narkabu*) is worked by placing a stick in a vertical slot near the outer circumference of the upper stone and turning it about on the lower one. This is still the practice of present-day Arabs.

There are a number of words in Akkadian and Sumerian which seem to denote different states of comminution (*teniti*, *sikite*, *pašate*, *ZID*, etc.). These different states were obtained partly by using millstones of varying hardness, such as basalt, sandstone, and granite.

[6] See ANDRAE, WALTER, "Die Archaischen Ischtar-Tempel in Assur," Leipzig, 1922, plate 19, No. 45.

[7] TOBLER, *loc. cit.*, Plate CXXXVII, Fig. 282.

[8] THOMPSON, R. C., "Assyrian Medical Texts," Oxford University Press, Oxford, 1923, p. 41.

The superscript *a* stands for *aban*, the determinative for stone.

[9] See GLUECK, N., "Explorations in Eastern Palestine," Annual of the American Schools of Oriental Research, No. 15, New Haven, 1935, p. 9.

[10] DALMAN, G. H., "Arbiet und Sitte in Palästina," Schriften des Deutschen Palästina-Instituts, III, Gütersloh, 1933.

[11] Cuneiform texts in the British Museum, IV, 30, 4*a*.

Figure 3

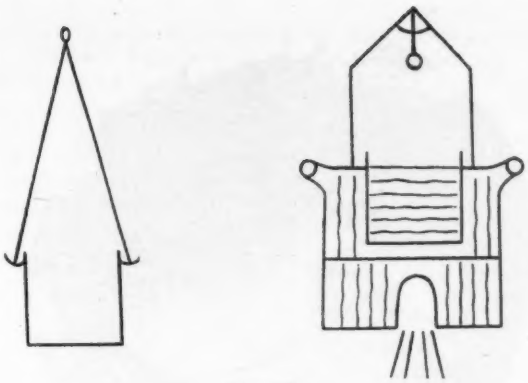

Figure 4

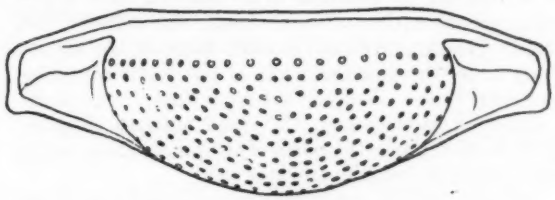

Figure 5

MISCELLANEOUS EQUIPMENT

Earthenware strainers were well known in ancient times in the Near East. An example from Nuzi[12] is shown in Figure 5. A colander for larger particles is depicted in Figure 6. For use as a filter the strainer was probably covered with wool or hair. This was the most common practice in Alexandrian and Arabic times. Filtration is mentioned in the earliest medical literature known, a text in Sumerian of about 2200 B.C.[13]

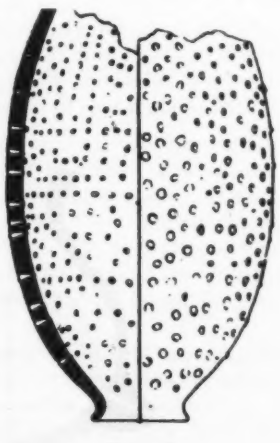

Figure 6

[12] Figures 5 and 7 are from STARR, RICHARD F. S., "Nuzi," Harvard University Press, Cambridge, 1937, Vol. II.

[13] LEVEY, MARTIN, "Ancient Chemical Technology in a Sumerian Pharmacological Tablet," J. CHEM. EDUC., 32, 11 (1955).

Figure 7

A very simple method of filtration which was known to the ancients is the use of a porous, unglazed clay vessel to contain the solution to be filtered. The vessel is then placed within a second one. The latter vessel would, of course, be glazed in order to retain the filtrate which seeps through the walls of the inner container after some time. Today in the Near East, where water is stored in earthen jars, the small amount of water which seeps through the pores of the jar and then evaporates keeps the remaining water cool.

Crucibles were known in Mesopotamia and were made mainly of fired clay. A metal crucible from Nuzi is shown in Figure 7. This is no different in design from our modern crucibles.

Drip bottles have been unearthed at Nuzi (Figure 8). These bottles have a characteristic spout with an opening of very small diameter placed very low on the body. This type of bottle would thus be "suitable for the administration or mixing of pharmaceutical preparations." These medicinals were compounded by the slow admixture of one substance with another, particularly when the final product was to be some kind of colloidal mixture.

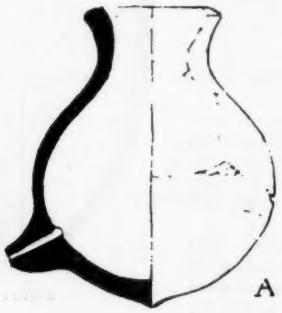

Figure 8

Apparatus for the separation of nonmiscible layers of liquids is shown in Figure 9. In later times this was referred to as a *separatorium*.[14] This was probably the type of apparatus used to separate the aqueous layer from the oil layer in the manufacture of perfumes.

Only a small part of the greatly diversified equipment of the ancient Mesopotamian chemical technologists has been mentioned. The literature clearly shows that the Mesopotamians were also acquainted with the balance and weights, spatulas, stirrers, molds, furnaces yielding a fairly high temperature, and various other important apparatus.

WOMEN IN ANCIENT CHEMICAL TECHNOLOGY

A question arises as to the possible origin of chemical apparatus, and its earliest users. In view of the fact that most of the equipment mentioned in this paper may be construed as having come either from an ancient kitchen or as having evolved from cookroom utensils, it is certain that women had an important place in early chemistry. It has already been pointed out that the earliest chemists (of 1200 B.C.) whose names we know were two women. Women were active in various branches of chemical technology until Alexandrian times when they achieved important positions in alchemy.

[14] See FERCHL, F., AND A. SÜSSENGUTH, "A Pictorial History of Chemistry," Wm. Heinemann, London, 1939, Plate 95, No. 49.

Figure 9

CONCLUSIONS

The knowledge of the ancient Mesopotamians, as seen from the nature of their apparatus, was very extensive in chemical technology. This is corroborated by the known literature, particularly the glass, perfumery, and medical texts. The fine clay and metal artifacts of the ancient civilizations of this area tend to lend weight to this conclusion. From the apparatus alone we may determine that the ancient Mesopotamian knew the essence of the arts of sublimation, extraction, and possibly distillation. Filtration and specialized methods of grinding were also extensively practiced. Separation of nonmiscible liquids was carried out either by decantation, as in the oldest Sumerian medical text, or by the use of a vessel with a spout near its base. The earliest chemical apparatus was developed, according to the best available evidence, to a large extent by women, from cookroom utensils.

USING THE HISTORY OF CHEMISTRY IN OUR TEACHING[1]

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As I see it after thirty years of teaching and supervising chemistry in our high schools, we are missing an opportunity to produce more and better scientists and more well-rounded citizens. Specifically, we are exhibiting the dry bones, and ignoring the spirit of chemistry.

I entered the field of teaching three decades ago. The school was a large coeducational institution in Jamaica, New York. Its student body was a clean-cut, intelligent one, marked with no more than average resistance to sustained learning. There was the traditional course of study in chemistry, the orthodox textbook, and the admonition by the principal—who himself had been a teacher of chemistry—to get those boys and girls through the State Regents Examination at the end of the school year.

The course of study was cluttered with isolated facts, barren formulas, involved industrial processes, and various applications and uses of innumerable chemicals. Interest was not high, and the results, as measured by grades based principally on periodic examinations which tested mainly facts, were nothing to write home about. The going was rough. I brought up my heavy artillery —my college notes in pedagogy, the psychology of learning, spectactular experiments, visual aids, projects, warning notes to parents, and threats of impending failure. There was very little improvement in the situation, and I was quite unhappy.

Interest, I knew, was a potent force in the fight for the minds of my pupils. How to get it? I analyzed my own experiences as a student of elementary chemistry. I had been stirred by a dynamic teacher, Dr. Charles Baskerville, one-time president of the American Chemical Society. He was not only a superb experimenter who handled the lecture part of the course, but he was also something of a scholar in the history of chemistry. This was easily apparent by the many references he made to the pioneers of chemistry, their approach to chemical problems, and their struggle to solve them. Mayow, Rey, Priestley, Lavoisier, Cavendish, Dalton, Mendeleev, Arrhenius, and Kekulé were figures in a new and thrilling story. This was the spark that kindled an interest in the lecture hall. In the recitation room this light was all but extinguished in the dreary recital and drill of a flood of *minutiae*—the melting point of sulfur, the boiling point of alcohol, the composition of Wood's metal, the construction of a Bessemer converter, etc., etc. The answer was then obvious. Sacrifice some of the sterile, nonessential facts for the cultural, humanistic, and imaginative aspects of chemistry.

A rich background was needed and I set out to get it. Soon I was using biographical material and other historical sidelights as a *motivation* in the teaching of chemistry. I really warmed up to this new tool; my enthusiasm carried over. Young people enjoy a good story. They cottoned to the new approach, and imbibed the more strictly factual information less pain-

[1] Presented at the 126th Meeting of the American Chemical Society, New York, September, 1954.

fully. I started out to overcome the lethargy of my classes, and as I pictured the development of chemistry as a product of human achievement I was thrust more and more into the role of a modest historian of chemistry. With additional reading, followed by more intense research, the great drama unfolded itself. A meaningless, frenzied quest for alchemic gold, a strange search for the elixir of eternal life, a bitter struggle against medical superstition, a centuries-long attempt to discover the nature of fire, the birth and death of the mischievous theory of phlogiston, the epochal discovery of oxygen, the final solution of the phenomenon of burning, the discovery of the composition of the atmosphere, the determination of the composition of water, the controversy over the unseen, little atoms of a Quaker schoolteacher, the discovery of some of the basic laws of chemistry, the change from the old hieroglyphics of alchemy to modern symbols and a sensible nomenclature, the battle over the molecules of a dead and forgotten Italian professor, and the first, short, crude list of atomic weights; then the synthesis of urea and the opening of a vast new world of creative chemistry, the daring prophecy of a Russian chemist and the search for new elements, ionization, X-rays, radium, electrons, protons, atomic numbers, neutrons, and finally, man reached into the inner citadel of the tiny atoms and released a new giant—atomic energy ready to be harnessed for the first time in human history. An arresting, dazzling tale which could not fail to stir the imagination of even the most complacent.

THE HUMAN STORY

Inextricably tied to these world-shaking advances was an even greater story—the human one—the saga of men groping for causes and struggling to frame laws; of men leading intellectual revolutions and fighting decisive battles in laboratories. Here was meaning, light, inspiration, life. "We are just now beginning to realize," Professor Dewey has written, "that the great heroes who have advanced human destiny are not the politicians, generals, and diplomats but the scientific discoverers who have put into man's hands the instrumentalities of an expanding and controlled experience."

The historical approach has also subtle, *inspirational* overtones. Few of our high-school boys and girls have had any real conception of the spirit of the men of science—the impelling sense of curiosity, the mighty guiding urge, and the all-consuming fire sustaining them during centuries of incessant labor. These pioneers dreamed of new worlds and trembled at new discoveries. "Research is not a religion, but the act of one," said Sir William Bragg, Nobel Prize winner in science. A visit to the Cavendish Laboratory in England in the opening years of this century, to the Radiation Laboratory of the University of California in the early thirties, to Los Alamos in the early forties, or to any one of the hundreds of laboratories around the world would convince anyone of the truth of this comment. Here men who might have been masters of industry, eminent diplomats, or famous lawyers are obsessed with the search for the nature of matter and energy and of their control and use for human advancement. To most of the millions who attended high school this world of the scientist was unknown.

HABITS OF THINKING

The use of the history of science in the teaching of high-school chemistry reached out even beyond its value for the sustaining of interest, motivation, and inspiration. As I dug deeper into the business of writing of the history of chemistry, I realized more and more that through this approach the more enduring goals of science teaching could be attained more successfully. I am certain that at the high-school level, at least, the most important objective of science instruction is to inculcate and spread more widely the habits of scientific thinking and acting. It is generally known that nearly all the facts and formulas of elementary chemistry disappear rather quickly. The scientists' method of approaching and solving problems has a better chance of being retained longer. An effective way to teach the methods of science is to show how our great scientists reached their goals and how their minds worked in the process. Chemistry is studded with examples of the spirit and methods of science, and offers striking illustrations of all of them. The controversy between Berthollet and Proust over the validity of the law of constant composition is a stirring story of men of science wrestling with a fundamental generalization, and struggling open-mindedly to arrive at the truth. The battle over the ions of Arrhenius is a perfect example of the critical, questioning attitude of the scientist in the hunt for a rigid explanation of many seemingly contradictory observations regarding the passage of electricity through solutions. In the fever heat of this conflict it took on the proportions of an international struggle which was finally settled not by physical power, false slogans, or deep-seated preconceptions, but rather by the cold testimony of flask and beaker, and the moving pointer on a dial. What better method is available to teachers for illustrating open-mindedness, freedom from prejudice, the willingness to give up old, cherished ideas when new and better ones are found, the facing up to a problem with courage, the realization that there is always the need to check and recheck, and the withholding of judgment until all the facts are in? Bertrand Russell, eminent mathematician and philosopher, once put it this way: "Whoever heard a theologian preface his creed or a politician conclude his speech with an estimate of the probable error of his opinion?" as every scientist is wont to do.

With a rich background of the history of chemistry, the sprawling areas of the chemistry course of study can be tied together and integrated into a united, vibrant whole. The origins, growth, and final fruition of ideas and principles are immensely important in science education and can best be taught by the historical approach. Most of our pupils view chemistry

"as they might a volcano, prepared for the eruption of some discovery from time to time, but accepting the effects of the eruption without realizing the processes which led up to it during the preceding period of quiescence."[2] Confronted with science as human achievement the pupil realizes that, to quote Albert Einstein, "Creating a new theory is not like destroying an old barn and creating a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connections between our starting point and its rich environment."

SCIENCE AND CULTURE

Writing on the history of chemistry for pedagogic purposes brought into clearer focus another issue. Is it justifiable, from any real set of values, for literature, history, art, and music to pre-empt the whole domain of the so-called cultural disciplines? Does not science have some powerful claims for inclusion in this intellectual world? The individual steeped in art, music, or literature is frequently a barbarian when it comes to an understanding of the masterpieces of science. He often freely admits it without fear of losing caste. On the other hand, the poor scientist who may be weak in his aesthetic appreciation or knowledge of the arts is usually ashamed of his weakness. Does this really make any sense in the light of the contributions of science to our culture, and the high, intellectual requirements of the scientist? Said George W. Gray, one of our best contemporary science popularizers: "The idea that science is something outside of humanity, or is of a lower order of human interest than poetry, painting, architecture, or the arts, is one of the oddest quirks of casuistry."

The use of the history of chemistry in pedagogy is important for still another reason. Half of our high-school population drops out before graduation from high school. Of the other half only a small percentage enters college and completes its education. All of these youngsters will become citizens. As such, in a democracy they can be enlisted to take a wise and active part in the support of constructive, scientific projects and enterprises such as new TVA's, flood control, and soil conservation. The extent and nature of the uses to which the new giant of nuclear energy is to be put can be determined better by those who have had some acquaintance with the history of scientific development and with the methods and spirit of science.

At a time when we live every moment in an atmosphere of peril, the need of a better informed and more scientifically oriented citizenry is of paramount importance. Gerard Piel, publisher of *Scientific American*, expressed this idea in another way. "Now that the taxpayer," he told the American Association for the Advancement of Science last year, "has assumed the burden of the financing of science, his well known enthusiasm for its mere utility must be offset by a deeper understanding of what science is. The people must be shown that science is concerned with the ends as well as with the means of human life."

A final reason for using the historical background in the teaching of chemistry is its value in the recruiting of science teachers, especially at this time when there is a very critical shortage of such teachers throughout the country. In a report issued late in 1953 by a distinguished group of science educators, "Critical Years Ahead in Science Teaching," one of the suggestions listed is for high-school teachers to work deliberately to encourage pupils to consider science as a vocation. "At present we are failing to make science in its broadest sense attractive to the high-school population," was one of the conclusions contained in last year's report of a committee of the Central Association of Science and Mathematics Teachers. I submit that this more inspirational method of teaching chemistry has a terrific pull on young people groping for future careers, and a better chance of recruiting chemistry teachers than the old traditional method. Many a young man or woman was started on this road through the inspiration of some chemistry teacher who was able to arouse his interest and enthusiasm through case histories and stories of the great pioneers of chemistry.

RESULTS

Writing on the history of chemistry for pedagogic purposes has already shown some modest results. Several chemistry textbooks already reflect this new approach. From the general acceptance of these textbooks it seems fair to conclude that teachers and pupils have taken kindly to it. Some attempt has been made here to aid the student to recapture the experiences of the pioneers of chemical advance. The future of this trend looks promising. For example, a few colleges have had or are now giving courses and degrees in the history of science including chemistry. The need for a new crop of teachers better prepared in this aspect of science teaching is slowly being met by such colleges as Brandeis, Brown, Bryn Mawr, Cornell, Dickinson, Harvard, Hobart, Johns Hopkins, Northwestern, Purdue, Princeton, Radcliffe, the Universities of Delaware, Minnesota, Pennsylvania, and Wisconsin, and Williams College. In 1947 James Conant, president of Harvard, joined with several other science teachers in giving a course in science based on a number of case histories in experimental science such as "The overthrow of the phlogiston theory," "The development of the concepts of heat and temperature," and "The atomic molecular theory." Professor Leonard Nash, one of the members of this panel, defended the new approach to science teaching as follows: "The public's misunderstanding of, and occasional antipathy towards science and scientists is a bitter reflection on the methods by which we have previously attempted to teach science. There is every reason to consider the possibility that some non-traditional approach to this problem may prove superior to the methods that have been our reliance in the past." I believe this makes sense.

[2] Prince of Wales before B. A. A. S. at Oxford in 1926.

MODELS OF PLANE MOLECULES[1]

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CERTAIN of the atom-model sets presently available commercially, such as the Fisher-Hirschfelder-Taylor sets, suffer from the limitation that some of the more complex ring systems such as porphyrin, phthalocyanine, and certain aromatic, fused rings cannot be satisfactorily constructed. We have found that useful models of such ring systems can be made relatively easily by taking advantage of the fact that they are planar. In brief, the outline of the molecule is drawn on a plank having the scalar thickness of the carbon atom and then is cut out as a unit. Provision is made for attaching side chains, which may be constructed from the atoms of the commercial kits.

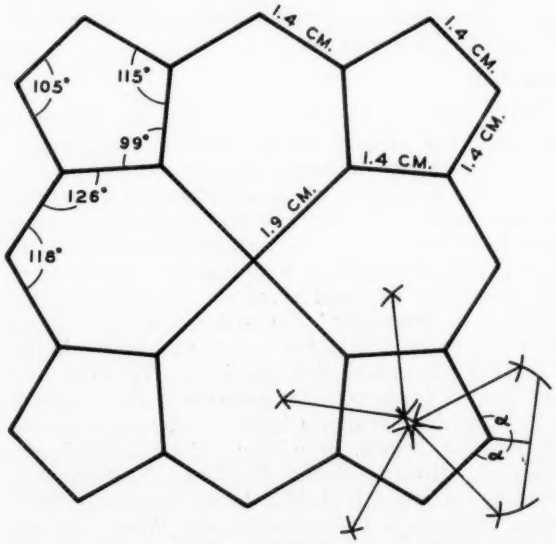

Figure 1. Locating Centers and Faces in Atoms of Porphyrin Model

The construction of the porphyrin ring is described to illustrate the method of constructing molecular models of planar rings. The ring was designed for chelation with iron.

The model is scaled one cm. to one Å. to conform with the Fisher-Hirschfelder-Taylor models. Bond distances and angles were taken from those determined for nickel phthalocyanine[2] with the following modifications:

(1) All distances were measured to the nearest millimeter.

(2) The central hole was altered slightly to accommodate iron instead of nickel. (Ferric iron was assigned a bond length of 1.2 cm.[3])

(3) The molecule was drawn completely centrosymmetric.

(4) The pyrrole rings were rendered somewhat more symmetrical, as might be expected with the removal of the fused benzene rings. The skeleton of Figure 1 resulted.

The intersections of the lines in Figure 1 give the locations of the centers of the various atoms. About these centers were inscribed circles having radii corresponding to those employed in the Fisher-Hirschfelder-Taylor sets. However, it was found that the pyrrole carbons tended to overlap in the center of the pyrrole ring, which is logically undesirable, so the carbon radius was shortened slightly to 1.1 cm. so as to practically eliminate the overlap. The radius of nitrogen was taken as 1.2 cm.

Faces between the atoms within the molecule were drawn as illustrated in Figure 1 (lower right pyrrole ring). External bonds for carbon and nitrogen were extended 0.7 cm. from the center of the atom[4]. The direction was assumed so as to make the angles α equal (Figure 1; only one external bond is shown).

Erasure of unneeded lines now gave the drawing illustrated in part in Figure 2. This was transferred to the surface of a smooth plank of maple wood, $^7/_8$ in. thick (approximately the adjusted diameter of the carbon atom), and the molecule was cut out on the jigsaw, removing wood inside the ring as indicated by the shading of Figure 2. A sharp-pointed tool was employed to inscribe the lines marking the C—C and C—N bond faces.

Shallow holes were drilled in the centers of the external bond faces of the molecule to receive the standard Fisher-Hirschfelder-Taylor clips (obtained from Fisher Scientific Company, Pittsburgh, Pennsylvania) using a simple homemade tool which cut a hole the shape of the clip. (The clips should fit snugly.) A small screw through the central hole of each clip was used to hold it tight.

The molecule was then sanded and painted to match the commercial atoms: nitrogen blue, carbon black. Since cobalt, the only metal atom available in our kit, is quite close to (covalent) iron in size, we have used it

[1] This investigation was supported by a research grant (RG-3752) from the National Institutes of Health, Public Health Service.

[2] ROBERTSON, J. M., AND I. WOODWARD, *J. Chem. Soc.*, 1937, 221.

[3] PAULING, L., "The Nature of the Chemical Bond," 2nd ed., Cornell University Press, Ithaca, N. Y., 1942, p. 182.

[4] *Ibid.*, p. 164.

instead of iron. The hole in the center of the porphyrin ring was carefully shaped so that the metal atom is held tightly by friction, yet may be removed when required.

In the same manner we have constructed models representing pyrrole, pyrromethene, imidazole, and purine. Except for pyrrole[5] there are no X-ray data available for these molecules, so we have had to assume what their shapes are. For instance, nitrogen is substituted for a carbon of the pyrrole ring to make imidazole, and pyrromethene is drawn from two pyrrole rings and a bridge carbon of the porphyrin ring.

It is interesting that when two pyrrole rings are joined by the C^4 (aromatic; benzene) carbon atom from the Fisher-Hirschfelder-Taylor set, the molecule corresponds quite closely to the pyrromethene molecule derived from phthalocyanine. Four pyrrole rings may be hooked together in this way to form a porphyrin ring.

It will be seen in Figure 3 in which our pyrrole is compared with the Fisher-Hirschfelder-Taylor benzene, that very little is lost so far as utility is concerned by not using rounded atoms to construct the rings. This holds so long as the atoms in the ring have very nearly the same diameters, as is the case with carbon and nitrogen. Were, say, thiophene to be constructed, in which case the sulfur has a diameter appreciably greater than that of carbon, it would be necessary to leave a gap in the ring for sulfur, shape the faces of a two-bond sulfur from the Fisher-Hirschfelder-Taylor models to fit the gap, and glue the sulfur in.

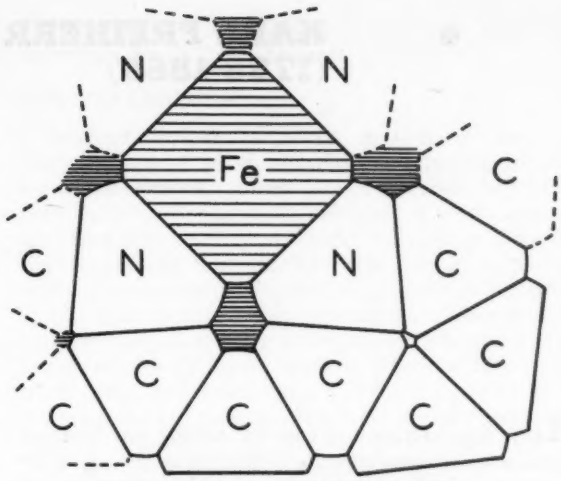

Figure 2. Final Drawing of Porphyrin Model

Obviously, the type of model described here is not limited to use with Fisher-Hirschfelder-Taylor atoms. The construction can be easily modified for use with any similar kit.

[5] SCHOMAKER, V., AND L. PAULING, *J. Am. Chem. Soc.*, **61**, 1776 (1939).

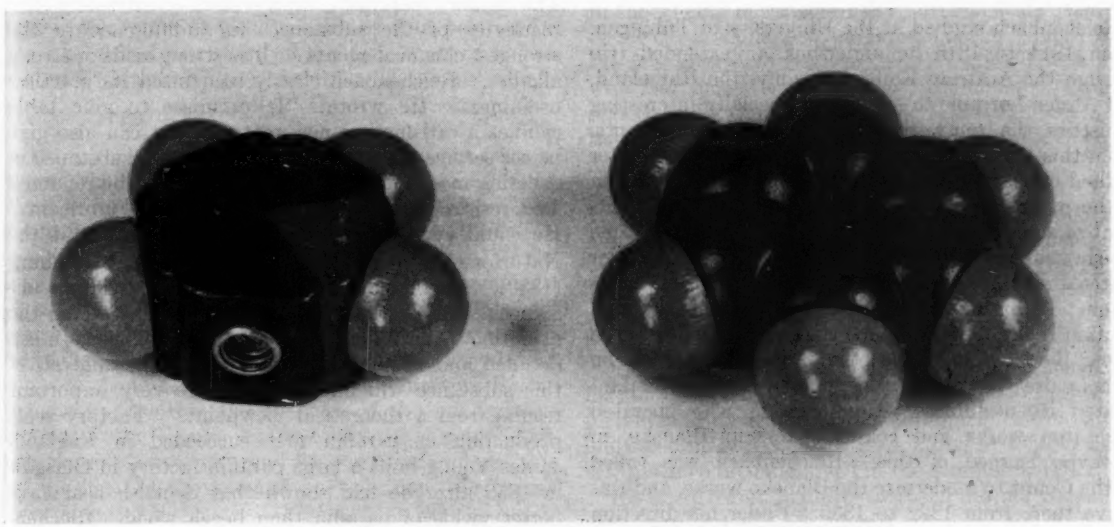

Figure 3. Pyrrole Model with One Hydrogen Removed, Compared with F-H-T Benzene

ERRATUM

ON PAGE 327 of our June, 1954, issue (Volume 31) is a picture of members of the Geneva Congress on Organic Nomenclature, 1892. The listing of the names in rows 1, 2, 3, 4 *should be* "from left to right" and not, as indicated, "from right to left."

KARL FREIHERR VON REICHENBACH (1788-1869)

Investigation of Paraffin (1830) and Wood Tar (1830-33)[1]

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(Translated by Henry M. Leicester)

KARL REICHENBACH is counted among the Austrian chemists. He was born in 1788 in Stuttgart, but for many years he lived in Austria and all his scientific work was carried out there. Not only did he make a name for himself as a chemist in science and industry, but he was also an investigator of unusual originality, versatility, and productiveness. In Austrian scientific and industrial circles there was a strong demand for a memorial to Reichenbach (1913). This monument was set up in 1917 in the Technical Museum for Industry and Trade in Vienna. Until now, however, there has been no evaluation of the life and work of this world-famous man in any chemical journal, although 86 years have passed since his death (1869).

Reichenbach studied at the University of Tübingen. From 1814 to 1816 he undertook an extended trip through the Austrian Empire, Saxony, the Rhineland, and Alsace-Lorraine to study the especially interesting industries, the iron works, and the wood-coking plants. From this trip he discovered how to establish a better method of coking by a modification in the construction of the ovens. He hoped to make possible the treatment of a greater amount of wood so that at the same time it would be possible to obtain a good yield of harder charcoal and of the liquid products of the dry distillation. In his method the wood underwent dry distillation in fire resistant stone chambers heated by iron pipes. The introduction of this process in conjunction with an already existing iron works in Germany had indicated its usefulness. Count Salm, who operated large iron works and coking plants at Blansko, in Moravia, learned of this. Reichenbach was called by the Count to modernize the Blansko works, and was active there from 1822 to 1836. Under his direction manufactures rose sharply, and the iron foundry soon became the greatest in Austria. Reichenbach obtained a considerable fortune from the resulting industrial activity and he used part of it for the purchase of several large estates. In 1835 Reichenbach also bought the Reisenberg property near Vienna. The mountain which is now called the Kobenzl belonged to this. Here Reichenbach lived in the summer, and, after he had given up his activity in Blansko, he spent the winter in Vienna.

In the years from 1830 to 1833 Reichenbach published in Schweigger's *Journal für Chemie und Physik* 18 contributions under the title "Contributions to the knowledge of dry distillation of organic substances" which resulted from his work in Blansko. In the very first of these papers was announced the important discovery of paraffin in beech-wood tar. On the basis of his detailed studies Reichenbach had given this substance the fortunately chosen name "paraffin" from the Latin words *parum*, "little," and *affinitas*, "affinity." The name "paraffin" expressed the extremely low reactivity of the substance—its indifference to the strongest chemical agents such as strong acids or strong alkalies. Reichenbach clearly recognized its practical usefulness. He wrote: "It promises to give table candles a satisfactory new material. It can also give better service than any previously known substance in covering materials and vessels which must be rendered acid resistant. It is the base for a good lubricant." He could even show a sample of his paraffin at the Naturforscher und Ärzteversammlung in Hamburg (1830). He thought that this was an individual substance. This work of Reichenbach had attracted the attention of Berzelius. Berzelius said: "This work is a detailed and very excellent study and the analysis of this substance will undoubtedly give very important results from a theoretical viewpoint." Factory scale production of paraffin first succeeded in England. James Young built a large paraffin factory in Glasgow in 1850 after he had shown that Scottish coal gave better yields of paraffin than beech wood. Riechenbach first learned of this in 1854 and could in the same year publish this fact, so gratifying for him, with full recognition of the great service of Young.

Later Reichenbach reported on the results of his investigations of the alkali-soluble part of beech-wood tar. He isolated an oily substance boiling above 200° which he called creosote. He characterized it as follows. "A small amount dissolved in water kills small animals. It is the mummifying principle of pyroxylic acid. Flesh dipped in the water solution no

[1] Presented at the 126th Meeting of the American Chemical Society, New York, September, 1954.
[2] Present address: 536 West 113th Street, New York 25, N. Y.

longer spoils. There is no doubt that it will find medicinal uses." He believed it was the preservative of meat in smoke. Creosote has found a place among the valuable drugs of medicine, dentistry, and veterinary medicine. Sollman, in his "Manual of Pharmacology,"[3] says: "It is more strongly antiseptic and antipyretic and rather less irritant than is phenol."

In 1834 F. F. Runge (1795–1867) discovered in coal tar a substance very similar to creosote. Runge named it carbolic acid, shortened from coal-oil acid, that is, an oily acid prepared from coal. Laurent later (1841) showed that pure carbolic acid is solid, and Gerhardt gave it the name phenol (1841). Reichenbach believed his creosote was identical with phenol. The work of Hlasiwetz (1858), H. Mueller (1864), and Gorup Besanez (1867 and 1869), however, showed that creosote is actually a mixture of creosol (4-hydroxy-3-methoxy-1-methylbenzene) and guaiacol.

According to Reichenbach's observations, beechwood tar also contained a higher boiling (285°)fraction. This was oxidized by Reichenbach, yielding two interesting dyes, *cedriret* (1834) and *eupitton* (eupittonic acid). Cedriret forms dark, steel-blue needles. C. Lieberman, who called this dye *cörulignon*, indicated that is is tetramethoxydiphenoquinone (1873). Eupitton is orange yellow; its beautiful blue alkali salts were named *pitakall* by Reichenbach (1833). The study of A. W. Hofmann (1878 and 1879) showed that eupitton is hexamethoxyaurin. A. W. Hofmann wrote: "It is known that Reichenbach, nearly a half century ago, in the course of his admirable work on beech-wood tar had called attention to the formation of a blue material which he called pitakall."

METEORITES

During his activity in Blansko, Reichenbach observed the fall of meteoric stones (1833) while at the same time a blazing meteor appeared in the sky. This event aroused his interest in the highest degree and he decided to take up the study of meteorites. As a result of this work there appeared in Poggendorf's *Annalen der Physik und Chemie*, from 1850 to 1865, 28 contributions, some of them very extensive. Rich factual material is contained here, unusually valuable for both chemist and mineralogist. In his work Reichenbach had needed the free use of the mineral collection of the Vienna Natural History Museum. He complained, however, that he was hindered in this by the head of the mineralogical division, the famous mineralogist Haidinger (1795–1871) who himself worked on meterorites. Haidinger was filled with petty jealousy toward the private scholar Reichenbach. Reichenbach's work on meteorites disturbed Haidinger. However, Reichenbach knew how to help himself. His great wealth made it possible for him to build up a large and costly collection of meteorites. Reichenbach donated this collection to the University of Tübingen (1858) which thereupon made him a Doctor of Science, after he had already in his youth obtained the Ph.D. from the same university.

[3] 1942, p. 658.

THE "OD-LIGHT"

Reichenbach had also begun, in 1844, to carry on investigations of psycho-physical and psycho-physiological phenomena. These can be described here only very briefly. Reichenbach published a great number of papers in this field, and several books, some of which were translated into English. He was an excellent writer who was inspired by the subject on which he wrote, and he knew how to inspire his readers. These studies had their beginning in the observation that some people could perceive the appearance of light in a dark room when others could not—rays of light emanating from the poles of an electric magnet, from the edge of a large rock crystal, and from the surface of some plants. This light he called the "Od-light." He believed that an all-pervading power of nature, a "world force" which he called "Od" had been discovered. His papers at first aroused great interest. Liebig published in the 53rd volume of the *Annalen* (1845) a long paper by Reichenbach in this field, and Berzelius, who met Reichenbach in the summer of the same year at Karlsbad, advised a complete investigation of the observations. However, the basis of the Od studies soon became shaky. Finally, seven outstanding Berlin professors, among them G. Magnus, Mitscherlich, Poggendorf, and G. Rose, in a statement published in the Vienna newspaper *Presse*, attacked the existence of the Od as an independent force of nature. This sealed the fate of the Od studies. We must ask how a man who had shown such sharp critical understanding in science could wander so far in the field of fantasy. Yet the history of science gives many examples of such errors by men of great mental capacity.

Reichenbach was called the learned sorcerer of the Kobenzl in Vienna. People in the neighborhood told how Reichenbach, clad in a long wide mantle, sometimes was seen to leave his castle in the hours of the night. With a thoughtful mien he went down the mountain to the cemetery of the near-by village of Grinzing to seek for the Od-light.

Reichenbach endured not only the breaking up of his studies of Od, but also the loss of a great part of his fortune and his estates owing to unlucky business and industrial activities. Death took him in 1869 in Leipzig, to which he had moved in the summer of 1867.

We must regret that Reichenbach did not remain in chemistry as he had originally intended and in which his best work was done. Many great honors were given Reichenbach. We only mention that the city of Stuttgart made him an honorary citizen and the Imperial Vienna Academy of Sciences in 1848 elected him to membership. Though he came from the class of poor citizens, he was raised in 1830 to the state of a baron. Yet the highest honor for Reichenbach came through himself. He has inscribed his name in eternal letters in the book of the history of chemistry.

THIS CULT OF BREVITY

JOHN H. WILSON, JR.
U. S. Naval Ordnance Test Station, Inyokern,
China Lake, California

WHAT is worse than gobbledy gook? Or at least just as bad? Excess brevity!

The word is out. Keep it short. Keep it concise. Boil it down. Keep it to a minimum. Too short? May be hard to follow? Anybody who has any business reading this will know what we're talking about.

But will he?

Always the pressure is on. After all, your reputation rests on the number of times you publish. Get it out. Get rid of it. Get the bare essentials down. Get it typed up and sent in. Get it in print!

What is the result of this perpetual pressure, this striving for concise, boiled-down papers? The result is that often your printed paper is not communication, nor the propagation of knowledge, but more than failure of communication—the propagation of confusion. No small part of this confusion is caused by the notion that clearness and communicability vary directly with conciseness and brevity. You can be too concise. You can be too brief.

Be too brief and the trouble starts. You assume the reader knows much more than he does. You skip everything but the highlights of what you have done. You give the reader the facts, the bare facts, the minimum of facts, and let him take it from there.

Fine if he is with you. Fine if he knows all the background; if he knows the setup; if he has read your previous papers; if he is an old-timer in the field and is not breaking into your specialty because of some offshoot of his own specialty that has unexpectedly led him here.

But what if all this is not true? What have you given your reader if he is not right in there with you from the start?

You give him confusion. You assume a background he does not have, and since he does not have it, all that you tell him is meaningless, or means less than it might, or means something entirely different from what you want it to mean. You have tried to communicate knowledge and you have communicated confusion—if you can call that communication!

There always is the perpetual pressure to *cut*. More symbols and abbreviations for words and entire phrases are adopted, created, and forced into the manuscript, past the editor, and into print. Words are cut out, then phrases, clauses, sentences, paragraphs, pages, and finally entire sections. What has happened? What does this cutting mean in terms of reporting results, the experimental situation, and the thought that has gone into the experiment and into the results? You have made it briefer all right. But has the treatment of the idea, the process, and the work done been cut to such an extent that your paper no longer makes sense? Does it convey the full meaning you want it to convey?

What a report writer is unconsciously assuming when he cuts his report to the bone is that anybody who reads the report has been through the work and the thinking that he has, step by step, so that everything he says is complet ly obvious. If that were so, then why write the report?

The more nonroutine the work, the material worked with, and the procedures followed, the more carefully you must fill in the background, the exact procedures, material, and equipment used in your presentation.

What makes the adequacy of treatment, the overclarification, even more important, is the cross-field work going on. A man starts on a line of investigation, everything goes smoothly, and suddenly he finds himself thrown dazed, bewildered, and probably peeved, into an alien field: from chemical spectroscopy to microbiology; from genes to crystal refraction of X-rays. You have to begin reading in a new field. Often that means reading what is almost a new language. At best it will be months before you are at home in the new literature. No research man needs to be told that this being thrown into a new field is increasingly typical.

This above all—be conventional. Use symbols, abbreviations, and phraseology that are common. If you want to be understood, the triter you are the better. Better to be a little awkward and circumlocutious than to jump right in with something "anybody can understand." When in doubt about usage, go to the dictionary, to textbooks, and to journals and find out what is used. Do not try to create new symbols and usages for yourself. Language only communicates when writer and reader get the same meaning from a word, a symbol, an abbreviation, a sentence, or a paragraph. And that mutual understanding is a matter of convention. The important thing is to form the habit of keeping your reader and the problem of communicating to him perpetually in mind.

INHIBITION OF CARBONIC ANHYDRASE BY THIOCYANATE

A Demonstration

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As part of a student experiment in biochemistry demonstrating the inhibition of carbonic anhydrase activity, it was deemed of interest to show the inhibition by thiocyanate which was first reported by Davenport (*1*) and later mentioned by others (*2, 3, 4*). Since the "boat" method of Meldrum and Roughton (*5*), for carbonic anhydrase was too cumbersome and complicated for general student use, a modification of the methods of Brinkman (*6*) and of Philpot and Philpot (*7*) was adopted as a simpler procedure. This method measured the rate of formation of carbonic acid from carbon dioxide and water as catalyzed by carbonic anhydrase.

To 25 ml. of distilled water in a large test tube was added one ml. of five per cent sodium bicarbonate, one ml. of 0.02 per cent bromthymol blue, and one ml. of the inhibitor solution (omitted in controls). This mixture was cooled to 4° C. in an ice bath. The carbonic anhydrase, in this case in the form of human blood, although blood from other animals would be suitable, was added after the cooling. Carbon dioxide from a cylinder fitted with a reducing valve was bubbled through the mixture and the time required to reach a color change from blue to yellow-green was measured. This reaction time is an inverse function of carbonic anhydrase activity. Since the reaction time will vary with the rate of bubbling, the carbon dioxide was admitted at the maximal rate that could be achieved without blowing the reaction mixture out of the test tube. Blank reaction times (*i. e.*, no blood added) under these conditions were almost invariably 11 ± 1 seconds. A Kipp generator using marble chips and hydrochloric acid can be used as a source of carbon dioxide, but the reaction times are longer and not as reproducible as those using the cylinder.

Varying amounts of blood were used to test the method and obtain a standard curve, typical results of which are shown in Table 1.

TABLE 1

Ml. of blood	*Reaction time (seconds)*[a]
0.10	1.7
0.08	1.7
0.06	1.7
0.04	1.8
0.02	2.8
0.01	3.7
0.005	8.4
0.003	9.8
0.001	11.1

[a] Averages of duplicate or triplicate determinations.

To test the effect of thiocyanate, one-ml. portions of one per cent and five per cent solutions of potassium thiocyanate were added under varying conditions. See typical results in Table 2. A trial with Dirnate, an exceptionally potent carbonic anhydrase inhibitor (*8*), was run for comparative purposes.

In an attempt to extend the reaction times and thus reduce the percentage error in measurements of reaction times, trials were made using two-ml. portions of five per cent sodium bicarbonate instead of one ml. This variation proved unsatisfactory since the end points were then much less sharp than with the lower bicarbonate concentrations. Phenol red was tried in place of bromthymol blue but again end points were not sharp. The presence of blood interfered more with phenol-red end points than with bromthymol-blue. However, reaction times with phenol red seemed to fall in about the same range as those with bromthymol blue.

From the tables one can see that it was possible under some conditions to have considerable inhibition of carbonic anhydrase without influencing the rate of the reaction it was catalyzing. In Table 1 it is apparent that 0.1 ml. of blood was a large excess over that amount necessary to achieve maximal reaction rates. The limiting factor with excess blood may have been the rate of diffusion of carbon dioxide from the bubbles into the solution. Not until the amount of blood was reduced below 0.03–0.04 ml. was there any detectable change in the reaction time. If, as was done in this experiment when it was first tried by students, the amount of blood used were 0.1 ml. and the data on the

TABLE 2
Reaction Time in Seconds

Added	*0.1 ml. blood*	*0.01 ml.*	*None*
No SCN	1.7	3.9	10.7
1% SCN	2.6	8.5	..
5% SCN	3.8	9.9	..
1% Dirnate[a]	10.9	..	..

[a] Sharp and Dohme trade name for *p*-carboxybenzenesulfonamide.

standard curve were not available, it would appear that thiocyanate had very little inhibitory action on carbonic anhydrase since the difference in reaction times was small compared to the difference with the blank. However, comparing results in the two tables, the reaction time for 0.1 ml. of blood with one per cent thiocyanate added was the same as that for 0.02 ml. of blood, indicating about 80 per cent inhibition. The time for 0.1 ml. of blood with five per cent thiocyanate added matches that for 0.01 ml. of blood, showing about 90 per cent inhibition. Note that even with such inhibition the differences in reaction times were small compared to the differences with the control times. When the amount of blood used was reduced to 0.01 ml., the inhibiting effect of thiocyanate solutions was immediately apparent since the differences in reaction times were appreciable. Reaction times with inhibitor present approached that of the blank.

It should be noted that Davenport (*1*) used chloroform extracts of red blood cells as a source of carbonic anhydrase, whereas this work used whole blood. He used a carbonic-anhydrase assay method which measured manometrically the evolution of carbon dioxide from carbonic acid (*5*). The method described here measures the reverse reaction, the formation of carbonic acid from carbon dioxide and water.

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RECENT RESEARCH ON THYROID HORMONE[1]

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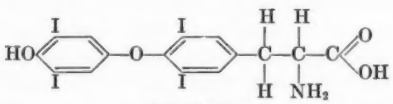
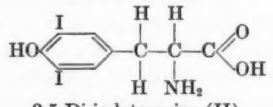
That the iodine-containing secretions of the thyroid gland exert a profound influence on total body metabolism has long been known; but, while much information is now available about hyperthyroidism (Graves' disease) and hypothyroidism (cretinism, myxedema), the major questions about the biochemical role of thyroid hormone are as yet unanswered. The answers cannot be simple, for thyroid hormone is concerned with several aspects of metabolic activity. Salter (*1*) and others (*2–11*) have recently written extensive reviews on the subject. As Salter has emphasized, thyroid hormone is not a single, simple chemical entity. Undoubtedly, however, the iodine-containing components of it, in association with thyroglobulin, are the key substances involved.

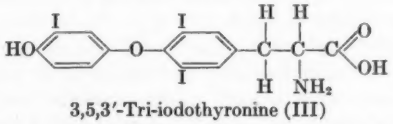
Crystalline thyroxine (I) was first isolated by Kendall (*12*) and synthesized by Harington and Barger (*13*). The L-form is the biologically active one. Diiodotyrosine was soon afterward found in thyroid tissue and its probable role as the precursor of thyroxine suggested (*14*). In 1948 mono-iodotyrosine was detected



Thyroxine (I)



3,5-Di-iodotyrosine (II)



3,5,3′-Tri-iodothyronine (III)

as a component of thyroid hormone (*15*) and just last year Gross and Pitt-Rivers (*16*) and Roche and his coworkers (*17*)—by radioautographic and chromatographic means—demonstrated the presence of tri-iodothyronine (III) in the serum of animals given

[1] Summary of a lecture presented before the symposium on The Relation Between Structure and Biological Activity, at the meeting of the American Association for the Advancement of Science, Pullman, Washington, June 23, 1954. The new work mentioned herein, from the author's laboratory, was supported by grants from Eli Lilly and Company and the United States Public Health Service.

prior injections of radioactive iodide. Compound III has several times the activity of I, both in the rat assay and in tadpole metamorphosis.

CURRENT TRENDS

While there was a lull in thyroid hormone research in the thirties (related to the increasing interest of endocrinologists in the steroid hormones) there has been remarkable renewal of interest in the past 10 to 15 years in the biosynthesis and biochemical effects of thyroxine and thyroxine analogues. The literature is voluminous (over 3000 publications related to thyroid in a one-year period during 1950–51) and the developments too numerous even to list here. A few of them may, however, be noted:

(1) Many new analogues and some isomers of thyroxine have been synthesized (*9*, *10*, *18*) and their biological activities assayed in amphibia and mammalia. In this way, new information has been gained about the minimum structural requirements for thyromimetic activity, but the problem is by no means solved (see correlation, below). Thyroxine analogues have become more readily accessible by means of an important modification of the synthesis of substituted diphenyl ethers developed by the Glaxo workers (*18*).

(2) Iodine tracer techniques, using I^{131}, have permitted progress toward understanding of the biosynthesis of thyroid hormone and of its metabolic fate. The papers of Chaikoff, Taurog, and their associates (*19*) and those of Rawson, of J. Robbins, and of Kirkwood (*20*, *21*), among many others, reflect the directions of some of these studies.

(3) The oxidative condensation of two moles of L-di-iodotyrosine (II) has been improved to the extent of becoming a feasible route to L-thyroxine. The mechanism of this reaction (*cf.* (*1*)) merits further study from the viewpoint of physical-organic chemistry and in relation to the biosynthesis of the iodinated thyronines. Studies of the *in vitro* iodination of tyrosine and thyronine have also been made, but the nature of the thyroid's "iodine trap" has not as yet been clarified (*cf.* (*20*, *21*)). The possibility that sulfenyl iodides (RSI) may be involved is suggested for consideration; the rapid formation of these, from thiol groups of proteins and iodine, may occur, and the possibility exists (*cf.* (*22*)) that the sulfenyl iodides could be effective iodinating agents.

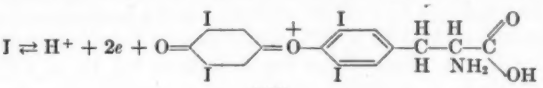
(4) Goiterogenic substances, such as the thiouracils and 2-mercaptoimidazole, have been developed, their mode of action partially resolved, and clinical applications have been made. The stages of the biosynthesis of thyroid hormone have also been partially revealed by means of these, since the goiterogens can inhibit certain phases of the biosynthesis.

(5) Considerable effort has been expended in the search for agents which could block the peripheral action of thyroxine without disturbing the normal pituitary-thyroid relation. The alternative objective, to find a substance which could control secretion of thyroid stimulating hormone (TSH) but which would not interfere with the peripheral actions of thyroid hormone, has also been pursued. Some progress toward finding "thyroxine inhibitors" (*6*, *18*) has been made, but the former efforts have not been successful. These studies appear worth pushing on with, however, because of their practical implications. Associated with such efforts are attempts to determine which enzyme systems are involved with thyroid hormone activity.

(6) Many of the clinical aspects of thyroid hormone as well as other studies, are presented by authorities in their special fields in (*8*) and (*11*). Iodine metabolism and its relation to thyroid function has assumed a prominent role in the clinical approach to various pathological conditions.

(7) An interesting field of related research lies in the question as to whether thyroxine or its analogues may have significant effects in species other than vertebrates. While attempts to reveal an unequivocal effect on invertebrates have failed, the recent work of Wainfan, Rittenberg, and Marx (*23*) concerning the effect of thyroxine on the rates of oxidation of cholesterol or glucose, in the aerobacter, *A. Aerogenes*, is of interest. If thyroxine analogues should also cause this effect, a convenient assay method may become available, and the effects of thyroxine in these supposedly simpler organisms may be suggestive of the mode of action of thyroxine in vertebrates.

(8) Niemann and co-workers (*9*) suggested a hypothesis of thyroxine action involving a redox equilibrium with a quinoid form (IV). The evidence which this has been based on, namely, the activity of the ortho isomer of thyroxine and the inactivity of the meta



(IV)

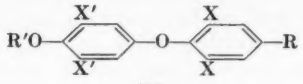
isomer (which could not form a quinoid form) has an interesting counterpart in the recent work of Bruice (*24*), who prepared a meta analogue of I, having a propionic side chain in place of the alanyl group, and reported that this compound has definite thyromimetic activity in the *Rana catesbeiana* test. The possibility that the activity found in this case is caused by a trace of the very active analogue (*26*), V (R′ = H; R = $-CH_2CH_2COOH$; X, X′ = iodine) must, however, be considered. A further test of the Niemann hypothesis would be the synthesis and complete assay of a methylene homologue of thyroxine (—CH_2— in place of the ether oxygen atom in structure I). Such a compound would also be of interest as a possible competitive inhibitor of thyroxine.

Inspection of the literature cited will reveal other significant trends in thyroid hormone research, mention of which has necessarily been omitted above.

A CORRELATIVE HYPOTHESIS

The recent work of Bruice, Winzler, and Kharasch (*10*, *25–27*), coupled with the literature on the activities of diphenyl ethers, such as V, suggested a corre-

lative hypothesis of the thyromimetic activities of compounds as V, versus their structures. The main



(V)

X,X′ = I, Br, Cl, F, H, CH_3, NO_2
R′ = H or CH_3
R = ionizable groups as alanyl, —COOH, —CH=CH—COOH, $—NH_2$, etc.

features of this correlation are:

(1) Physical parameters which appear sufficiently dominant to base a correlative hypothesis on are: (*a*) the group dipole moments of X, X′ and —OR′, (*b*) the hydrogen-bonding abilities of X and X′, and (*c*) the ionizing tendency of R.

(2) If R is kept constant (*e. g.*, R = D, L-alanyl), R′ = H or CH_3 and X, X′ = halogen only, plots of log per cent activity versus the sum of the resultant group dipoles ($f\,\mu$) of X, X′ and R′O—, in the forward and prime rings, give a reasonably linear relation—both for amphibian and mammalian response.

(3) Relation number 2 does not hold if X or X′ represents H, CH_3, or NO_2. However, if graphically obtained (empirical) correction factors, *h*, are determined and added to $f\,\mu$ (*i. e.*, if $f\,\mu + h$ is now used) then analogues having substituents H, CH_3, or NO_2 in the X, X′ positions can be plotted together with those of section 2, above. The values of *h* ("hydrogen bonding factor") are positive—indicative of a positive effect on activity—if the substituent groups bond more strongly than halogen (*e. g.*, if X = NO_2); and *h* is negative for groups such as H or CH_3, which cannot form hydrogen bonds. A single value for *h* suffices for H or CH_3 in the 3, 5 positions, and another single value (less negative) can be used for H or CH_3 in the 3′, 5′ positions—suggesting the greater importance of hydrogen bonding in the 3, 5 positions. Thus, electron releasing substitutents in the 3′, 5′ positions can increase thyromimetic activity (*cf.* (*26*)); and compounds having $—NO_2$ substituents in the 3, 5 positions can show distinct thyromimetic activity, the unfavorable dipole function being partly compensated by the positive value of *h* for the nitro group. The greater activity of compounds with R′ = H versus R′ = CH_3 is ascribed to the greater electron-releasing ability of the hydroxyl versus the methoxy group. The unusually high activity of tri-iodothyronine (*15*, *25*) is not, however, anticipated on the basis of this correlation.

(4) If, in a series of molecules related to V, only R is varied, thyromimetic activity *for amphibian response* is highest (130 times D, L-thyroxine) for the analogue having the propionic acid side chain, $—CH_2—CH_2—$COOH, and activities are lower for compounds having side chains such that their acidities are either greater or less than the propionic acid analogue. This relation includes groups as $—CH_2—CH_2—$COOH, —CH=CH—COOH, —COOH, $—NH_2$ etc., but not the bifunctional alanyl group. On this basis, it appears that penetration versus ionization are important factors in determining thyromimetic activity of molecules related to V, maximum activity (in amphibian response) being exhibited by that molecule which has the most favorable structure for penetrating in the nonionized form and exerting its activity in the ionized condition.

The above correlation and discussion indicates a picture of thyroxine analogue action, in which the analogue binds to an active site (presumably an enzyme surface) through the ionized side chain and, primarily, through the groups in the 3, 5 positions—the binding of the back ring being of lesser importance. Once attached, the function of the thyroxine analogue (whatever this may, indeed, be) appears to be related to the electron density of the diphenyl-ether nucleus.

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A SURVEY OF SHORT COURSES IN ORGANIC CHEMISTRY[1]

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THIS survey was conducted by the Organic Subcommittee, Examinations Committee, Division of Chemical Education, in the spring of 1954, to determine: (1) the interest among college teachers in a standardized test for a short course in organic chemistry; (2) the course contents and the time allotted to individual topics; and (3) the effect on the course of the professional objectives of the students. Three hundred ninety-five questionnaires requesting pertinent information were sent to 38 junior colleges, 255 colleges, and 102 universities offering a one-term organic course. One hundred forty-five replies out of 226 indicated an interest in the test varying from a willingness to participate in its construction to possible usage.

The content of any course is frequently influenced by the textbook, the laboratory manual, the length of term, and the hours per week in the class and laboratory. Twenty-two textbooks and 28 laboratory manuals had been adopted. Among the textbooks the two foremost were used by 35 per cent and 12 per cent of the schools, which represented 46 per cent and 12 per cent of the student enrollments, respectively. The two most frequently used laboratory manuals had been adopted by 20 per cent and 10 per cent of the schools, which represented 17 per cent and 16 per cent of the student enrollments, respectively. Approximately 18 per cent of the teachers within each kind of school preferred to prepare their own laboratory work sheets. The student enrollment was nearly 6200, with classes having from four to 600 enrollees, whose professional goals were primarily home economics, medicine, dentistry, agriculture, and nursing, with others having an interest in engineering, chemistry, biology, and teaching.

The prerequisites to the one-term organic course were from three to ten semester hours of general chemistry, with 55 per cent of the schools requiring a minimum of eight hours. A few schools required a working knowledge of qualitative analysis. Seventy-five per cent of the schools offered the course for one semester (15 to 18 weeks), 17 per cent for one quarter (10 to 12 weeks), and 8 per cent for two quarters (22 to 26 weeks). Seventy-one per cent of the schools had three lectures per week, 20 per cent had two lectures per week, and 9 per cent had four or five lectures per week. Three to six hours per week were set aside for laboratory work by 80 per cent of the schools, while 12 per cent had one to two hours of laboratory or demonstration and 5 per cent had no laboratory work associated with the course.

The table presents the percentage of time devoted to the more important individual topics. The time was approximately the same for all three types of school and was in remarkable agreement whether the aliphatic and aromatic series were taught separately or simultaneously. The apparent overemphasis upon the hydrocarbons may be attributed to the time consumed in introducing nomenclature rules, organic structures, or other concepts necessary to the understanding of organic chemistry. The ratio of time for the aliphatic series to that for the aromatic series averaged nearly three to one.

Percentage of Time per Topic

Topic	*Two series taught together*	*Two series taught separately*
Hydrocarbons	20.6%	16.7%
Acid derivatives (esters; fats; amides; halo-, hydroxy-, and keto-acids; acid halides and anhydrides)	13.5	12.7
Aldehydes, ketones	10.4	9.3
Alcohols, phenols	9.5	9.3
Acids	6.4	6.9
Carbohydrates	6.9	6.0
Amines	6.1	5.9
Halogen derivatives	4.4	5.5
Proteins	4.8	4.2
Nitrogen derivatives (nitriles, nitro-cpds.)	2.3	3.7
Ethers	2.4	3.0
Applications, sources	1.0	2.3
Formulas (structural)	2.4	1.8
Dyes	1.5	1.4
Synthetic problems	0.3	1.3
Plastics, rubber	1.6	1.2
Reaction mechanisms	1.1	1.1
Sulfur derivatives	0.7	1.1
Heterocyclics	0.3	1.0
Vitamins	1.7	0.7
Stereoisomerism	0.5	0.7
Sterols	0.3	0.4

In summary, the ratio of time spent upon the fundamental topics in organic chemistry was affected only in a small degree by the type of school, length of course, textbook, or professional goals of the students. The construction of a standardized test will be undertaken, employing the data of the table, which probably represents the scope of the course but not necessarily its intensity. In addition, it is hoped that the above figures may provide a useful guide to teachers in the distribution of their time and in the development of the organic course content.

[1] Presented at the 126th Meeting of the American Chemical Society, New York, September, 1954.

COUNSELING THE WOMAN CHEMISTRY MAJOR[1]

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For most teachers, one of the pleasant aspects of teaching is helping a young man, even an average young man, plan a career in chemistry that will capitalize on his strong points and minimize his weak ones. But many a teacher has excused himself for neglecting the difficult task of helping his women chemistry majors plan realistically for careers by philosophizing:

"Teaching chemistry to girls is just a waste of time. They'll never use it. They'll just get married. They're only going to college to snag a man anyhow."

If there ever was a valid excuse for such an attitude, there certainly is not now. Any girl who majors in chemistry today is really interested in the science and wants it in spite of the odds against her.

She fully realizes that chemistry is, in general, a man's field. She knows what happened to women chemists during the depression and after both World War II and the Korean episode. She has heard the complaint that a woman chemist must be twice as good as a man to get 80 per cent of his salary. She knows that, while petticoats may not prevent a climb to the top in chemistry, they do make it "darned" hard.

The average woman chemistry major of today has chosen this difficult field in spite of the fact that she frankly admits that marriage is her primary goal. As a college woman, her chances of marrying are greater than they have ever been before, and she is likely to marry at a much younger age than have previous generations of college women.

In 1940 about half of the American women workers were married, and in 1953 two-thirds were. Although she expects to work after she is married, the woman chemistry major knows that marriage will probably interrupt, impede, or even end her chemical career. But she will spend the required time studying it because she expects to be repaid in satisfaction, as well as money, even though her chemical career may be very short.

Labor-saving devices have made it possible for a woman to combine marriage and a career, but to date no one has invented an automatic, full-time baby tender. That a career woman today has less than half the chance of finding a nursemaid or housekeeper that her stay-at-home mother had partly explains the fact that the greatest increase in women workers between 1940 and 1953 was in the 35- to 54-year-old group. Women of this age group have usually raised their families to a point of approximate self-sufficiency.

The task facing the counselor of the usual woman chemistry major is a formidable one, because it involves trying to help her choose a career that will:

(1) Give her a maximum of satisfaction in return for a minimum of preparation, preferably a bachelor's degree but at most a master's degree.

(2) Let her capitalize on her feminine characteristics and not penalize her in unfair competition with men.

(3) Give her a satisfying degree of success in the three or four years she expects to devote to a job between graduation and her first baby.

(4) Be a realistic insurance policy against disaster, in that she can return to it in an emergency without the need for extensive and expensive refresher courses.

(5) Give her a warm and human relationship with co-workers that, if necessary, will compensate for what most young girls consider the ultimate disaster—a life of single blessedness.

The familiar jobs of high-school teaching and technical secretarial work meet some of these requisites, but in some respects fall short. There are jobs for women chemists that will meet the five requisites listed; however, I do not think such jobs will be found in laboratories. Indeed, the happiest and most successful women chemists I know are what Mary Alexander, of Universal Oil, once called "Chemists without test tubes": chemical writers, editors, literature searchers, librarians, administrative assistants, and patent searchers. In my opinion, a job in one of these five "chemical-service" fields is most likely to satisfy the needs of today's woman chemistry major.

Since the requirements and rewards in these fields are so similar I would like to confine any detailed discussion to the one most familiar to me—technical editing.

By technical editing I mean only the style editing of technical material, because the scientific value and logic of technical reports are evaluated by supervisors before the reports reach the technical editor. The technical editor is a technical grammarian, but she is more than that. She is an expediter of ideas. It is her job to see that the ideas of the research or production chemist, for instance, reach management, the scientific world, or customers as efficiently and attractively as possible.

Probably more technical editors are employed by government research agencies, universities, research foundations, and the research departments of large industries than are employed by publishers of scientific and engineering journals and textbooks. The government is the biggest "consumer" of technical reports, and hires more technical editors than any other group.

[1] Presented before the Division of Chemical Education at the 126th Meeting of the American Chemical Society, New York, September, 1954.

Technical editing is a field in which the woman scientist will not find her sex a handicap, because it is such a new field that men have not become so firmly entrenched as to resent feminine competition. Technical editing really came of age just before and during World War II when the government let research contracts to private, industrial, and university research laboratories, with the requirement that periodic written reports be submitted on the progress of the research. Highly specialized technical curricula seldom include training in report writing, and the average scientist or engineer is not a born writer. So most government contractors were forced to hire technical editors to polish the reports turned out by their research workers.

Although technical editing is a field in which a woman with a bachelor's degree can compete, it should not be considered a refuge for laboratory misfits. Just as the qualifications of a good research chemist differ greatly from those of a good production chemist, so do the qualifications of a good report editor.

Few schools offer courses in technical journalism, so one who needs an editor is faced with the dilemma of hiring either an English major or a science major. It would seem to be much easier to take a good science major and teach her a few fundamentals of editing, and this has proved to be true in my experience. However, all too often the appalling truth of the matter is that one must teach the science major the fundamentals of English grammar, too. When I need an assistant my preference is a chemistry major from a liberal-arts college, because her English background is more likely to be adequate than that of a technical-college graduate. Fundamentally, a good editor of chemical reports must have good foundations not only in chemistry and English, but in mathematics and physics as well. Since good reports are very dependent on the presentation of data, at least one course in statistics would be a worthwhile addition to any report editor's education.

Technical editing, writing, literature and patent searching, and library and administrative work have in common certain qualifications that are traditionally attributed to women: desire to serve or help others, patience with routine, capacity for handling meticulous details, willingness to serve without glory, and facility with words.

A very important part of a technical editor's job concerns personal relations. An editor's job is a touchy one because she must be able to correct a writer's mistakes without antagonizing him. In many respects she is in a position like that of a mother trying to convince her child that spinach tastes good because it is good for him.

To make the job even harder, research workers universally regard reports as necessary evils—in fact, some will not even grant that they are necessary. Once a piece of research is done, most scientists are less interested in reporting it than they are in using the results to solve a new problem. A scientist can be particularly irked by the idea of writing a monthly report on work he has now decided was useless. He would rather spend the time developing a new method for solving the problem.

In 1952 starting salaries for technical editors probably ranged from $300 per month, for a person with a bachelor's degree with a strong science major and no laboratory experience, to about $400, for a person with some laboratory or engineering experience as a background for editing reports. A recent survey reported that a salary of about $650 per month is the average for the profession. Since many organizations believe that an editor's salary should be in line with the salaries of those whose reports she edits, a salary of $1000 per month is not unlikely. It must be admitted that men are more likely to get the maximum salaries, but the salaries paid women are very attractive and usually better than those paid women laboratory workers of comparable training and experience.

Technical editing would seem to me to be an ideal insurance policy against disaster. An editor does not shelve her grammar when she retires to housekeeping, and when she returns to editing she learns by doing because each report helps to bring her scientific knowledge up to date. In fact, it is even possible for a technical editor to continue editing even though she is confined to her home. One editor left Armour Research Foundation, where I am employed, in 1949, but five years and three babies later she still has all the extra work she can handle delivered to her door when one of the Foundation's present editors gets swamped. Another editor who is being retired by the stork plans to edit and type theses for graduate students at a university near her home.

Technical editing should be an even better family substitute for the older woman than the time-honored one of teaching, because as a technical editor she would serve and work with not only the young but also her contemporaries. Also, it is a field in which she can gain both professional and financial satisfaction. Although one may succeed with only a bachelor's degree, additional degrees should bring additional rewards.

Technical editing is definitely a growing field. In 1946 when I came to Armour Research Foundation there was one other woman editor here. Now there are ten of us. There are opportunities in the field in most industrial and university cities. Until the recent cutbacks in the government services, Washington, D. C., was a Mecca, the place where all good little report editors hoped to go.

There is an organization of over a hundred technical writers and editors in Boston alone. A national group was organized in Washington, D. C., at a meeting of the American Documentation Institute last November. The American Association of Agricultural College Editors has a membership of more than 300, and hopes to have 400 within the year.

The other chemical service fields I have mentioned (writing, literature and patent searching, and administrative and library work) seem equally rewarding to the women I know who are working in them. I do hope that you will advise your women chemistry majors to consider such fields as possible careers early in their chemistry training.

PERIODIC CHART BASED ON s p d f ELECTRON DISTRIBUTION

GROUP	K 1s (2)	L 2s (2)	L 2p (6)	M 3s (2)	M 3p (6)	M 3d (10)	N 4s (2)	N 4p (6)	N 4d (10)	N 4f (14)	O 5s (2)	O 5p (6)	O 5d (10)	O 5f (14)	P 6s (2)	P 6p (6)	P 6d (10)	Q 7s (2)
I A	1 H	3 Li		11 Na			19 K				37 Rb				55 Cs			87 Fr
I B							29 Cu				47 Ag				79 Au			
II A		4 Be		12 Mg			20 Ca				38 Sr				56 Ba			88 Ra
II B							30 Zn				48 Cd				80 Hg			
III A						21 Sc			39 Y				La - Lu 57 71				89 Ac	
III B		5 B		13 Al				31 Ga				49 In				81 Tl		
IV A						22 Ti			40 Zr	58 Ce[2] 59 Pr[3] 60 Nd[4] 61 Pm[5] 62 Sm[6] 63 Eu[7] 64 Gd[7] 65 Tb[9] 66 Dy[10] 67 Ho[11] 68 Er[12] 69 Tm[13] 70 Yb[14] 71 Lu[14]			72 Hf	90 Th[0] 91 Pa[0] 92 U[0] 93 Np[5] 94 Pu[5] 95 Am[7] 96 Cm[7] 97 Bk[9] 98 Cf[9] 99 -- 100 -- 101 -- 102 -- 103 --			
IV B		6 C		14 Si				32 Ge				50 Sn				82 Pb		
V A						23 V			41 Nb[4]				73 Ta[3]					
V B		7 N		15 P				33 As				51 Sb				83 Bi		
VI A						24 Cr[5]			42 Mo[5]				74 W[4]					
VI B		8 O		16 S				34 Se				52 Te				84 Po		
VII A						25 Mn[5]			43 Tc[6]				75 Re[5]					
VII B		9 F		17 Cl				35 Br				53 I				85 At		
VIII A						6 7 Fe-Co-Ni 8 26 27 28			7 8 9 10 Ru-Rh-Pd 44 45 46				6 9 9 Os-Ir-Pt 76 77 78					
INERT GASES B	2 He	10 Ne		18 A				36 Kr				54 Xe				86 Rn		
PERIOD →	1	2		3			4			5				6				7

LANTHANIDES 4f ELEMENTS

ACTINIDES 5f ELEMENTS

A PERIODIC CHART BASED ON *s p d f* ELECTRON DISTRIBUTION

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THE plan of this periodic chart was developed in a slightly different form independently by the author during the period of the middle 1930's to 1942. The purpose was to provide a *tool* from which to teach advanced inorganic chemistry to college classes of senior chemistry majors. A chart with a similar arrangement of the elements was first published by Mitra[1] who used the older spectroscopic notation, and included many tie lines to indicate the electron addition sequence in filling of the various orbitals.

Since the principles involved in the filling of electronic orbitals have been described in previous papers, the plan of the chart should be at once apparent. The elements are arranged according to increasing atomic numbers in vertical columns beneath the respective *s p d f* sublevels. Numbers in parentheses denote the maximum number of electrons in the particular series of orbitals when completely filled. Only one rule is necessary to follow the sequence of atomic numbers: *After the last element in Group VIII (both A and B subgroups) return to the top of the chart to the* s *orbital in the next higher quantum group.*

The atom of the first element in all *s* and *p* columns will have, in its ground state, only one electron in this outer orbital, the atom of the second element will have two in the outer valence level, the third in the *p* column, three, etc. This arithmetical rule is obeyed for all *p* orbitals. In the case of the *d* and *f* orbitals there are many exceptions. In these exceptional cases, according to standard notation, a superscript is written to the right of the symbol of the element to denote the number of orbital valence electrons. If no superscript is written the electron distribution follows the arithmetical rule.

The positions of the *lanthanide* and *actinide* elements in the chart demonstrate that these elements belong to series in which the presence of *f* electrons influences their properties. Since the first elements, cerium and thorium, in these series of elements have, in their tetravalent states, chemical properties like those of Group IV-A, they are placed horizontally with the elements in Group IV-A to show homology; however, it should not be construed that the series are members of Group IV-A. Lutetium, element 71, has the electronic configuration $4f^{14}\ 5d\ 6s^2$, so is written in the $5d$ column to show its homology to other elements in Group III-A. The *lanthanides* are generally considered as a separate group. The +3 oxidation state is a common characteristic. Except in a few cases it is probably better to regard the series separately rather than relating the elements as homologues of elements of Group III-A. There are disagreements in assigning electron configurations to the atoms of thorium, protactinium, and uranium, some presuming that $5f$ electrons make their first appearance in protactinium, the latter having the configuration $5f^2\ 6d\ 7s^2$, and uranium $5f^3\ 6d\ 7s^2$. The recent papers by Seaborg and others,[2] and by Dawson[3] probably give the latest data on the present status of the actinides, and their analogies to the lanthanide elements.

The form of a periodic chart depends upon the purposes for which the chart is to be used. The chart described in this paper is merely the conventional periodic table rotated 90 degrees with the order of the elements reversed. A change in perspective often emphasizes properties differently. In this case the emphasis is now upon *groups* rather than *periods*. For example, instead of viewing a horizontal row of 18 elements beginning with potassium, arranged in the order of increasing atomic numbers, one observes in the horizontal rows the ordinary family groups of elements with like distribution of *s p d f* electrons, and like chemical properties.

There are certain advantages to this arrangement which merit consideration. Periodicity with increase in atomic numbers is retained, but with more emphasis upon the order of study of the groups of elements as they are usually presented in textbooks. The similarities in electronic configuration for each group of elements are clearly shown, and the electron distribution for the atoms of each element is readily obtainable. For example, the $2p$ elements may be written in the expanded electronic configuration forms as shown for nitrogen.

$$\begin{array}{cccccc} & & 2s & & 2p & \\ 7N & (\cdot\cdot) & (\cdot) & & (\cdot) & (\cdot) \end{array}$$

Both the number of unpaired electrons available for normal covalencies and paired electrons for coordinate covalencies are clearly shown, illustrating the difference in valence properties of the elements, and demonstrating the fundamental *rule of two*. Similarly, comparisons can be made for the $3d$ elements, and the relationships of copper and zinc and their homologues to the transitional elements by deriving the *d s p* bond orbitals. Applications to structural inorganic chemistry are numerous. This arrangement of the elements is advantageous for deriving electronic configurations and predicting the number and kind of directed bond valencies.

[1] MITRA, S. K., *Phil. Mag.*, **11**, 1201 (1931).

[2] SEABORG, GLENN T., ET AL., *J. Am. Chem. Soc.*, **76**, 1416 (1954); "The Actinide Elements," McGraw-Hill Book Co., Inc., New York, 1954, Vol. 14-A, part IV.

[3] DAWSON, J. K., *Nucleonics*, **10**, No. 9, 39 (1952).

THE FLUID DUPLICATOR

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AN EXTREMELY valuable tool in chemical education and an interesting example of applied organic chemistry are combined in the modern fluid or "spirit" duplicator. Postwar improvements in both mechanical design and in supply materials make available several good outfits for office use. With at least 300 copies obtainable from a single modern "master" sheet, examination questions may be written for large classes.

Even in a small class of 20 the product of a fluid duplicator is much more satisfactory than a set of questions written on a blackboard. In this writer's department it is now the universal custom to spread such questions over two, three, or four sheets of paper, with adequate space allowance after each question. This does not mean regimentation of answers by filling in blanks. The plan does, however, provide a complete document, question and answer, which is very convenient for grading, classroom "postmortem," and office conferences.

Special types of question are facilitated by this process. For example, one may easily sketch a thermometer, graduated from $-40°$ to $+50°$C., shown as partially immersed in a *cold* liquid. A companion thermometer of ordinary type is pictured hanging free in the open air. The question is brief: "What is the true temperature of the cold liquid?" No verbal prompting is required, suggesting the numerical values to be used for stem correction. The student is faced with the problem in the natural manner in which he might meet it in the laboratory, and has to select his own data. Numerous other applications of the duplicator are almost obvious.

OLD-TIME DUPLICATORS

The fundamental principle of the fluid duplicator is not new, but the essential combination of ideas embodied therein had to wait for fruition long after World War I. A survey of the main types of duplicating processes and machines has been given by Herrmann,[1] including the fluid or spirit devices.

The discovery of methyl violet, and of crystal violet, which is apparently the most intensely-colored substance known to man, led promptly to the "indelible" pencil and the quaint copying method of the nineteenth century. For example, the railway station agent of 1890 had a bound book of tissue paper in which he inserted the latest bill of lading, written with a pencil whose "lead" contained methyl or crystal violet. A damp cloth was laid upon the tissue sheet which rested on the bill. The tissue, slightly moistened, picked up enough of the dye to yield a copy legible from the top of the tissue.

Next came the "hectograph," in which crystal violet became a component of the coating of a special carbon paper. The purple image on a carbon copy from this source was then transferred to an awkward gelatin pad, which in turn theoretically yielded 100 copies, tediously stripped from the pad.

Not until the late 20's did somebody, in what the patent office calls a "flash of genius," devise the scheme of moistening blank paper with an organic solvent of limited solvent power, and then pressing that moistened paper against a hectograph "master sheet" or crystal-violet carbon copy. Obviously the master had to be done in reverse, like the face of a printer's type form. This German invention reached the European market as the "Ormig" machine, and soon attracted commercial attention in America. Beginning with the "Standard" machine in 1931, American competition appeared not only under the Standard trade name, but also others including Ditto, Rexograph, Old Town, Wright, Wolber, "Copy +," Duplikopy, Heyer, and Dick (Azograph).

With the exception of the new (1953) azo modification all of these machines play the same role. A master sheet of special, smooth white paper receives the typed or hand-drawn image, done in reverse. The machine then lightly moistens a sheet of slightly absorptive blank white copy paper with the properly chosen alcoholic fluid, and immediately presses this paper against the master. This process not only may, but *must* proceed rapidly, before the alcoholic film can evaporate appreciably. Rapid, efficient copy service is thus available, especially from electrically-driven machines.

DUPLICATOR CARBON PAPER

During the 1930's there were commercially available separate sheets of the dye-loaded carbon paper and of blank master paper, each chosen to give maximum clearness and neatness of letter image. Shortly there came a demand for more copies per master, and the carbons were more heavily loaded with dye. Still more pressing was the complaint of office women about soiled hands, and it became necessary to consolidate master and carbon in one fold-over unit which did not have to be shuffled. Although some special, lightly-inked master carbons are now on the market, this writer has been unable to produce as clean-cut lines on fluid-duplicator copies as he could in 1938. Blue, green, red, and even black carbon paper are now available, but none of these is equal to the crystal-violet product.

[1] HERRMANN, I. A., *The Office*, April, 1951, p. 9.

The continued complaint of office workers about soiled hands has led to the very recent commercial offering of master sheets in which the coating of crystal violet is water-proofed, but, of course, not rendered alcohol-proof. Such a master deposits little or no color on moist hands, to the satisfaction of the office people.

DIAZO PROCESS

Recently, Klimkowski and Florence[2] have reported their findings in an attack on the soiled-hands problem from a new quarter. These workers do not use a ready-prepared dye in the carbon paper. They incorporate into the paper and fluid the separate organic intermediates which, after typing and placement in a machine, finally get together and synthesize the color stuff as the copies are made. The classical azo-dye coupling reaction was chosen for the procedure. The "carbon" coating, instead of being made of crystal violet and adhesives, contains as principal material the powdered double salt of zinc chloride and the relatively stable diazonium salt of *p*-aminodiethylaniline. From this carbon paper a reverse master is typed as usual. Since the diazonium salt is somewhat acidic, it will not couple in the particular reaction to come until an alkali is added.

In the duplicator machine, instead of a simple alcohol or blend of alcohols, an alcoholic solution of phloroglucinol, or similar phenol or phenols, and diethanolamine is applied to the white copy paper. Contact of the diazonium salt in the typed image with the phenol immediately yields the expected azo dye at the high pH value assured by the diethanolamine. In another modification of the process, the diazonium salt is placed in the "carbon" coating, while the phenolic coupling agent is incorporated in a special copy paper. The fluid contains only alcohols and the pH regulator. Recipes for red and blue colors are given by Klimkowski and Florence.

Apparently the azo process has met considerable favor with those insisting on clean hands. Unfortunately, the limit of 50 copies per master, as contrasted with 300 or more by the crystal-violet process, is at present a drawback. Azo dyes are not nearly so intensely colored as the triphenylmethane derivatives.

DUPLICATOR FLUIDS

The principal constituent of duplicator fluid has been synthetic methanol, which alone yields good copies. Two disadvantages are noted here: first, toxicity, not serious if the duplicator workroom is well ventilated, or use of the machine only occasional. Serious headaches and illness were reported where one ill-advised office worker operated a machine in a large closet under a stairway. McAllister,[3] an industrial hygienist, in a critical analysis of hazards in atmospheric pollution by duplicators, ends with the flat advice: "Spirit duplicators should not be used in confined areas such as small offices without exhaust ventilation," and recommends "an enclosing hood over the receiving basket."

The second disadvantage, if such it can be called, arises from the fact that methanol is somewhat too good a solvent for crystal violet. Bright, well-inked copies are available, but few in number because the master image wears out prematurely. Only 200 copies might come from use of methanol with its high hydroxyl content, whereas 300 or more could have been obtained from a commercial, blended fluid.

Manufacturers of the machines furnish proprietary fluids in which the dye solubility is restricted to an appropriate level, with lighter, but still acceptable intensity of inking. Although these fluids are somewhat high-priced, it is advisable to employ them unless the users have enough technical familiarity with organic solvents to make sure that a homemade mixture does not contain either nonvolatile, oily impurities, or corrosive acid, and will not evaporate fractionally. Commercial fluids of higher solvent power are sometimes offered as options. Although some fluids have been patented, it is extremely doubtful whether a patent on a mere mixture of well known organic solvents would hold up in court.

Bjorksten[4] has reported in detail on the problem of blending alcoholic solvents for duplicators. The obvious suggestion of substituting ethanol, a compound of less water-solvent power, for methanol, proved not to be a simple remedy. Blurring of copy images resulted. Furthermore, federal law does not authorize use of educational, tax-free ethanol for such purposes. Common denatured alcohol is not acceptable, causing fouling of machines and possible corrosion.

Remedies proposed by Bjorksten include the addition of a nonvolatile alkanol to prevent blurring, and, according to Bjorksten's theory, to "plasticize" the crystal-violet carbon mixture. Where ethanol is available, partial or even complete elimination of the methanol is possible through addition of Methyl Cellosolve, pinacol, or 2-methyl-2,4-pentanediol to the ethanol.

DUPLICATING MACHINES

In view of current market uncertainties in this field, purchasing agents may note the following gratuitous advice for whatever it is worth:

(1) Do not pay much attention to the salesman's numerous "talking points" on nonessentials. The function of a fluid duplicator is actually very simple, and the all-important aim is to do this one operation steadily and uniformly without costly service calls for adjustment. Such items as metal, glass, or plastic fluid containers, square or round, on top or on the side, precision of copy register, trick valves or paper holders, or streamline appearance are minor considerations.

(2) The heart and soul of the duplicator lie in the mechanism for applying the alcoholic fluid to the copy

[2] KLIMKOWSKI, R. J., AND R. T. FLORENCE, U. S. Patent 2,634,677 (1953).

[3] MCALLISTER, R. G., *Am. Ind. Hyg. Assoc. Quart.*, 15, No. 1, 26 (March, 1954).

[4] BJORKSTEN, J., U. S. Patents 2,228,108 (1940), 2,262,488 (1941), and 2,294,711 (1941).

paper. Do not buy a duplicator in which adjustment of this mechanism cannot be done by the office woman after simple training. The mark of a poor duplicator design is seen when copies come through lightly inked near one margin and dark near the other, *in spite of proper attention to cleanliness of machine* by the office worker.

Some of the best duplicators use cloth wicks to convey fluid to the roller which wets the copy paper directly. The most critical scrutiny by the buyer should be directed toward the position of the wick, and the manner in which the fluid is delivered to wick and thence to roller, so that neither too much nor too little fluid is delivered to the entire surface of roller and paper.

(3) If you foresee use of the azo modification with its chemically-treated fluid, insist on a machine with stainless-steel roller for application of the chemically reactive material. Brass rollers, in common use, will serve for crystal violet but not for the diazo process.

(4) Despite the great advance in prices of mechanical equipment since the war, regular stock models of fluid duplicator are selling today at prices not exceeding those of 1939, and often much less. This obvious cut in real price has been accomplished by elimination of such luxuries as substantial castings and machined steel gears. The buyer should thus watch out for excessively light, pressed-metal parts in places where wear is heavy.

LINEAR POLYMERS AND STATISTICS

A Laboratory Experiment

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IN ALL fields of science the importance of statistical considerations is well recognized and growing. This has been especially true in the development of the extensive theoretical concepts of high polymers, such as their molecular weight distribution, the random end-to-end distance of polymer molecules, the behavior of polymers in solution, and gelation and elastic phenomena.[1] The concept of configurational entropy is one to which all beginning students of physical chemistry should be introduced, as well as to the extent to which chance and probability influence the course of chemical reactions and the structures of chemical compounds.

The laboratory experiment described here was designed to acquaint students with these concepts at the same time that elementary considerations of statistical thermodynamics were being discussed in the classroom. The results were so satisfactory that a description of the experiment is given here. The experiment, all of which could be finished within a three-hour laboratory period, consisted of three parts.

[1] FLORY, P. J., "Principles of Polymer Chemistry," Cornell University Press, Ithaca, N. Y., 1953, contains an extensive discussion of the application of statistical methods in high polymer theory.

TABLE 1
Expected Molecular-weight Distribution in the Model Linear Condensation

Number of structural units per molecule, x	*Number of molecules containing x structural units*	
	$p = 0.5$	$p = 0.794$
1	8.75	1.48
2	4.25	1.15
3	2.06	0.88
4	1.0	0.68
5	0.48	0.52
6	0.23	0.40
7	0.11	0.31
8	0.054	0.24
9		0.18
10		0.14
11		0.11
12		0.08
13		0.06
14		0.046

EQUIPMENT

The following, inexpensive pieces of equipment were required for each student:

(1) One inexpensive toy roulette wheel with steel ball,

(2) One die,

(3) 36 wooden model carbon atoms with tetravalently spaced holes,

(4) 36 wooden pegs to link the model carbon atoms together,

(5) Meter stick, yard stick, and foot or centimeter rule.

PART 1: MOLECULAR WEIGHT DISTRIBUTION IN LINEAR CONDENSATION POLYMERS

In many chemical systems the growth of molecules, their orientation, and their structural configuration occur largely by chance, so that statistical calculations

of high accuracy can be made concerning their properties. Such a system is illustrated by a dibasic acid, such as adipic acid, combining with a diamine, such as hexamethylene diamine, to give a polyamide or 6,6-Nylon. The molecular-weight distribution in Nylon has been shown to agree accurately with theoretical expectations based purely on chance. For a small number of reacting monomers, as must naturally be the case in a wooden model condensation, the molecular distribution can be calculated from the equation[2]:

$$N_x = (N_o - x + 1)p^{x-1}(1 - p)^2 \qquad (1)$$

where N_x is the number of molecules containing x structural units, N_o is the initial number of structural units before reaction (35 in this experiment) and p is the extent of reaction or the number of bonds formed divided by the total number of possible bonds for complete reaction (34 in this experiment). Table 1 contains calculated values of N_x using equation (1) for the case of half the bonds formed, p equal to 0.5, and for p equal to 0.794, 27 bonds formed out of a total of 34 possibilities.

The details of carrying out the experiment are as follows: First, the 35 wooden balls are numbered from one to 35, either with a glass-marking pencil or by numbered, small white labels. Second, the roulette wheel is spun and the number of the location where the ball lands is noted. Numbers 0, 00, and 36 are ignored, *i. e.*, the wheel is respun if the ball falls on these numbers. The position of the ball is used instead of the number when the wheel comes to a stop, inasmuch as the toy roulette wheels are not perfectly balanced and consequently do not give a perfectly random performance. Third, the model atom corresponding to the number spun is selected, and a wooden peg is inserted into it. Fourth, another number is spun, and the atom corresponding to this number is chosen and attached to the peg (the free valence). Fifth, the wheel is spun again and a new model atom is selected and a peg stuck into it. Sixth, another spin of the wheel enables the selection to be made of the fourth atom to be added to the peg in the third atom. After a model atom has two pegs attached to it, it is completely saturated chemically, so that if its number is spun, this number is ignored and the wheel spun again. Spinning the number of a saturated atom corresponds to a collision without reaction between a monomer and polymer. If the number of a bound atom comes up before it has two other atoms attached to it, a peg is inserted into the atom and it is attached to the atom whose number comes up on the next spin. In this way a chain of five atoms, let us say, may be joined to a chain of seven, to make a chain 12 atoms long. At no time should there be more than one free valence (peg) available for bonding an atom.

It is a help to make a table or rough sketch listing the atoms selected and their positions in the molecule so that, as the roulette wheel is spun, one can tell at a glance whether each number has been spun before or not.

The spinning of the wheel and the formation of the polymer molecules are continued until 17 of the 34 pos-

[2] For a short introduction to probability theory and its application to the calculation of molecular-weight distributions in linear condensation polymers, see DOLE, M., "Introduction to Statistical Thermodynamics," Prentice-Hall, Inc., New York, 1954, Chaps. 2 and 3.

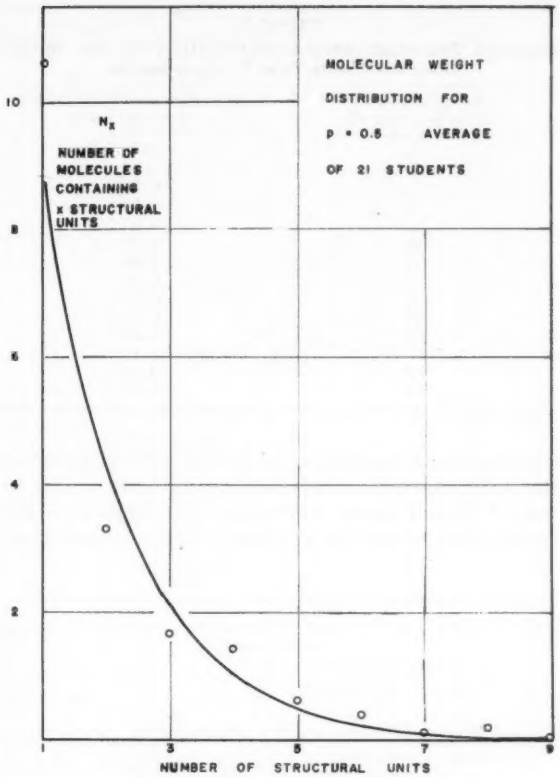

Figure 1. Comparison of Molecular-weight Distribution for a 50 Per Cent Model Polymerization

Solid line was calculated on the basis of probability. Circles are average results of 21 students.

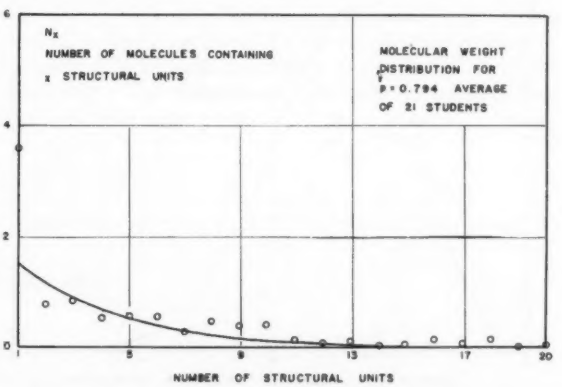

Figure 2. Comparison of Molecular-weight Distribution for a 79.4 Per Cent Model Polymerization

Solid line was calculated on the basis of probability. Circles are average of 21 students.

TABLE 2
Expected Molecular-weight Distribution in the Model Ethylene-Oxide Type Polymerization

Number of structural units per molecule	*Number of molecules containing x structural units*
x	N_x
1	0.04
2	0.20
3	0.50
4	0.84
5	1.05
6	1.05
7	0.87
8	0.62
9	0.39
10	0.22
11	0.11
12	0.05
13	0.02

sible bonds are made (p equal to 0.5). After recording the molecular-weight distribution in a table similar to that of Table 1, more numbers are spun until 27 of the possible bonds have been formed. Again, a molecular-weight distribution table is made and the results are compared with the theoretical expectations.

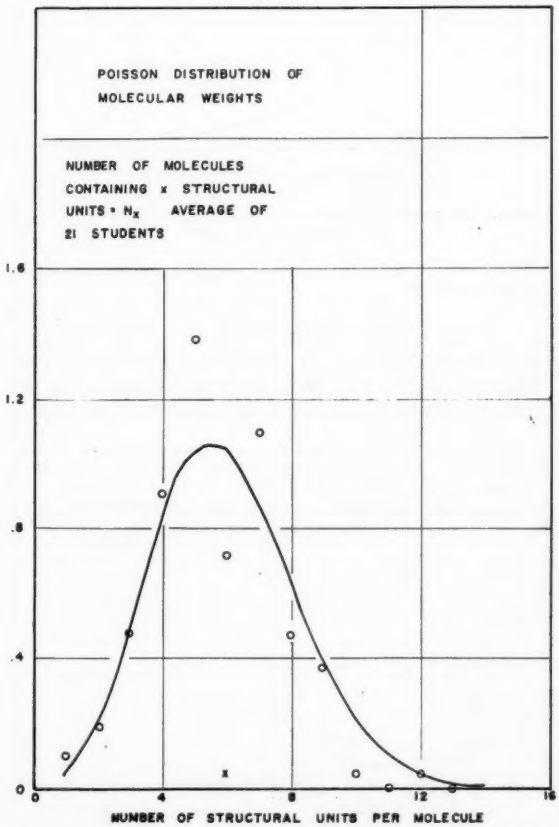

Figure 3. Comparison of Molecular-weight Distribution in an Ethylene-Oxide Type Model Polymerization

Solid line is the theoretical Poisson distribution. Circles are average results of 21 students.

Each student will probably be disappointed to find that his own distribution is far from the calculated value but, on the other hand, he will be equally interested to note that the average distribution for the whole class does fit that calculated by equation (1). Figures 1 and 2 illustrate average distributions for the two values of p obtained in a class of 21 students. The agreement with the purely theoretical distribution is excellent.

PART 2: MOLECULAR-WEIGHT DISTRIBUTION IN ETHYLENE-OXIDE POLYMERIZATIONS

Ethylene oxide polymerizes by reactions of the type:

$$ROH + CH_2CH_2O \rightarrow ROCH_2CH_2OH$$

$$ROCH_2CH_2OH + CH_2CH_2O \rightarrow ROCH_2CH_2OCH_2CH_2OH$$

If the initial reaction with the initiating molecules ROH is fast enough, the number of propagating molecules remains constant during the polymerization, and equal to the number of initiating molecules originally introduced. The relative growth of each molecule then becomes a matter of chance and the molecular-weight distribution can be shown[1] to follow the Poisson distribution law:

$$N_x = \frac{N_o e^{-\nu} \nu^{x-1}}{(x-1)!} \qquad (2)$$

where N_x is the number of molecules containing x structural units (counting the initiator as one unit), N_o is the constant number of polymerizing molecules (equal to the number of initiating molecules—taken as six in this experiment), ν is the total number of monomers reacted per initiating molecule (taken as 30/6, or 5 in this experiment) and e is the base of the natural logarithms. Table 2 gives the expected distribution.

To carry out this type of model polymerization, select the model atoms numbered from one through six and let them represent the initiating molecules. Roll one die and add one model carbon atom to the initiating molecule having the number on the top face of the die. Keep rolling the die and adding the model atoms to the chain whose number comes up each time on the die. This is done until all the 30 available model atoms (monomers) have been built onto the chains. The chains will now contain the six initiating model atoms plus 30 model monomers.

Again the molecular-weight distribution obtained by any one student may be disappointingly far from a Poisson distribution, but the average results for the class as a whole will scatter rather well about the theoretical Poisson curve, as illustrated in Figure 3.

PART 3: THE STATISTICAL END-TO-END CHAIN LENGTH OF TWO-DIMENSIONALLY ORIENTED LINEAR POLYMERS AND THEIR CONFIGURATIONAL ENTROPY

Imagine a model molecule of a linear polymer lying on

a desk top with each bond randomly oriented either to the right or left as one looks toward the bond from the point of view of the previous bond. The position of each structural unit can be expressed by two coordinates so that the model molecule can be considered to be two-dimensional. Theory[1] shows that the end-to-end distance should increase in proportion to the square root of n, where n is the number of links. All steric hindrance should be absent. This interesting conclusion of statistical theory can be tested by the following experiment.

Take a model atom, lay it on the desk top in such a way that two of its free valences point either to the right or left in a plane parallel to the desk top. Add a model atom either to the right or left depending on whether heads or tails comes up on tossing a coin. Continue to build the molecule adding the model atoms, depending on the results of the coin tosses, either to the right or left as one looks along the preceding bond, until 33 of the model atoms have been build into the chain (including the initial one). If the molecule doubles back on itself, the model atoms may be allowed to lie on top of each other. Attempt to make the bond distances of all bonds as nearly alike as possible.

The shortest distance between the center of the first atom and the center of every fourth subsequent atom in the chain, *i. e.*, between the first and fifth, the first and ninth, etc., is measured with a meter stick. The ratio of each of the subsequent distances measured to the first distance measured should increase in the order $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$, etc. These ratios will vary greatly from student to student, but the class average should show the $\sqrt{n}$ dependence, as illustrated in Figure 4. In Figure 4 the dotted line indicates the exact $\sqrt{n}$ relation while the solid line is drawn through the average results of the class. The end-to-end lengths are slightly greater than expected theoretically. This may be the result of steric hindrances in the doubling back of the model molecules, or it may be caused by accidental lengthening of the bonds as the model molecule becomes long and unwieldy. At any rate, the result is very satisfactory considering the crudeness of this experiment.

The configurational entropy of the structure is calculated from the equation:

$$S = R \ln \Omega \qquad (3)$$

where S is the entropy, R the gas constant, and Ω the number of orientations available to the molecule. The problem of calculating Ω is left to the student.

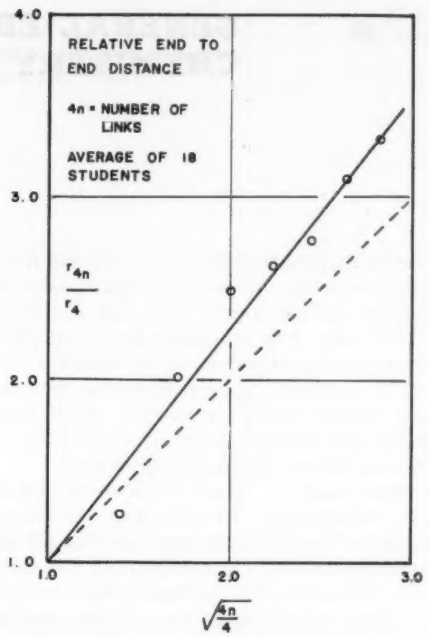

Figure 4. Relative End-to-end Distance for a Two-dimensional Linear Polymer

Dotted line is most probable distance. Circles and solid line are average model measurements of 18 students.

CONCLUSION

In conjunction with the laboratory experiment described above, the following experiment to illustrate entropy is done on the lecture table. A number of rubber bands are linked together and hung in a vertical position with a weight attached to the bottom so as to extend the rubber band to a distance about three times the initial relaxed length. On heating of the rubber, much to the astonishment of the students, the bands contract, raising the weight. The negative free energy of this process is then explained in terms of the increase in entropy due to configurational changes of the rubber molecules. This is a demonstration that the student will remember for a long time.

AN AFTER-DINNER TRICK

You are at the dinner table. Dessert is about to be served. The table is cleared except for the salt and pepper and cream and sugar, and the water glasses in which reside cubes of ice. A little diversion is wanting. Supply each guest with a short length of string, say two or three inches (or with a piece a foot long if you wish). The problem is to remove a cube of ice from the water glass, *using the string*. Warning: No knife, spoon, or fork is to be used, and no loop tied about the ice!

—Julius Sumner Miller, El Camino College, El Camino College, California

GENERAL EDUCATION AND GENERAL CHEMISTRY[1]

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ALTHOUGH the general education movement has undergone widespread development in the past few years, only infrequently has its impact been felt in professional chemical circles. The discussion by Hered (*1*) is most welcome in calling attention to the need for the incorporation of aspects of general education into the conventional general chemistry course. While in general agreement with Hered's point of view, I feel that it would be desirable to amplify his discussion.

The terminology in almost all fields of education is somewhat ambiguous. In particular, the terms "general education" and "liberal education" are frequently used interchangeably. At the heart of the philosophy of general education lies the belief that there exists a common body of knowledge that all educated persons must share. While there is no specific agreement on the goals of general education in science, a perusal of the literature in this field (*2*, *3*) suggests that some knowledge in the following areas would generally be accepted as desirable:

(1) The facts and theories of the physical world,
(2) The spirit and methods of science,
(3) The philosophy of science,
(4) The role of research in society,
(5) The aesthetic aspects of science.

That an educated person should be acquainted with many of the salient facts and theories that form the content of the scientific enterprise will arouse no disagreement. It is likewise a truism that knowledge of the "scientific method" is desirable. But it is now generally recognized that there is no specific method that scientists use in their quest for new knowledge. Rather, this goal would be better expressed as the appreciation of the spirit of scientific inquiry or, as Conant (*4*) states it, "the tactics and strategy of science." All that can be hoped for is some understanding of the relevant factors by which science is advanced. Any attempt to describe in precise terms the complex psychological processes that lead to the construction of new experiments or to the formulation of new hypotheses is premature.

Though the precise specification of the psychological aspect of science, *i. e.*, science in the process of discovery, cannot now be achieved, the logical aspects of science can be discussed with reasonable clarity. For once the hypothesis is formed its validation by empirical test of the logical consequences becomes, in principle, straightforward. The discussion of this process would form one part of the third goal, *i. e.*, an introduction to the philosophy of science. In addition, the limitations of scientific inquiry should be emphasized and the tentative nature of scientific theories asserted.

In a free society, the expenditure of large sums of money for research must have public acceptance; consequently, an understanding of the role of research, basic and applied, and its relation to technology is an important aspect of general education.

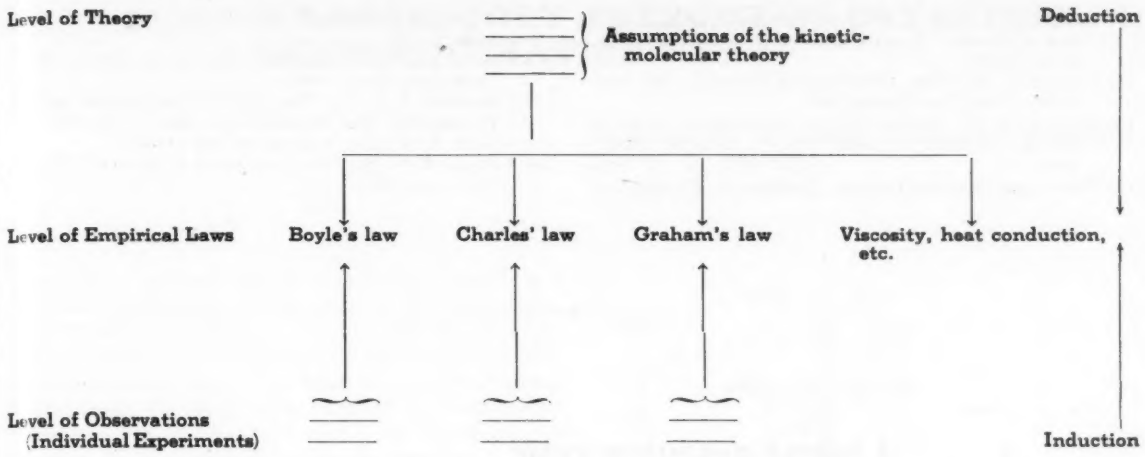
And finally, to dispel the notion that the scientist is cold and unemotional in his work and that science is a dull, albeit necessary pursuit, some understanding of the emotional and aesthetic aspects of science should be inculcated. That science is an intellectual adventure every bit as exciting as philosophy, literature, or art should not escape the attention of the college student.

To achieve these goals, nonscience majors are usually required to take a special course "about science." With an already crowded curriculum it is generally impracticable for the science major to do likewise. It might well be argued that the science student will ultimately, by virtue of his training, obtain this general education and in a more thorough manner than his nonscientific brethren who take the general education course. If one has in mind the relatively few individuals who become research scientists, this view is probably correct. But what of the large bulk of those in the general chemistry course, those future doctors, dentists, engineers, foresters, etc.? This group must be exposed to the general aspects of science in the "specialized" science courses or not at all. Fortunately, the general chemistry course is well suited to this task.

Naturally, the content of the course would satisfy the first goal. As Hered (*1*) has pointed out, much can be accomplished by the way in which the content is presented. However, I believe it to be of value to present general education topics in a more formal manner, first by specific discussions and then by repeated reference in connection with later discussions of course content. Unfortunately, students usually fail to "soak up" ideas unless they are forcefully brought to their attention. *By way of illustration* the following suggestions may be of value. Every teacher will use his own approach and examples, of course.

The study of gases provides an ideal opportunity for a discussion of science in the process of discovery (the scientific method) and in the process of verification (the philosophy of science). For an insight into the scien-

[1] Presented as part of the Symposium on Cultural Values of Chemistry at the 126th Meeting of the American Chemical Society, New York, September, 1954.



tific method, the historical, case-history approach (*4*) is particularly valuable. The development of the concept of a gas and the formulation of the gas laws provide a suitable base for this exposition (*5*). After the inductive (psychological) approach has been explored, the hypothetico-deductive (logical) method can be introduced by way of the kinetic-molecular theory. The power of this latter method can be clearly shown by noting that at least three separate "laws" (Boyle's, Charles', and Graham's) are direct consequences of a few assumptions. In this connection a distinction between description and explanation can be made. A useful clarification of these terms has been made by Feigl (*6*). The experimental facts (description) are "explained" if they can be derived from theory. The distinction between the inductive and deductive approach can be driven home by means of the diagram.

Another important aspect of the philosophy of science that merits attention is that of the limitations of science. Student interest in this topic is high and is further stimulated by asking students to judge the truth or falsity of a number of statements. In one group are statements of a factual character. These can be adjudged as true, false, or unknown, *e. g.*, "bromine is red," "water is denser than lead," "more than 67 per cent of the inhabitants of the world weigh more than 157 lbs." While the answers to the first two questions are evident, the answer to the last is unknown. It would be a waste of time to determine the answer, but there is no reason why it could not be found. On the other hand are statements such as "murder is wrong," "the food at Bates' is good," "God is all-knowing." It is fairly easy to point out that the answers to these questions depend upon value norms or ethical standards. As only factual questions may properly be put to science, the area of scientific inquiry is thus delimited.

The pseudo-conflict between religion and science can be effectively resolved at this point. Useful source material for this topic can be found in books by Von Mises (*7*) and Northrop (*8*).

It is especially appropriate in these days when science is worshipped for the material goods it produces and where there is widespread mistrust of the theoretical scientist engaged in basic research, that some time be devoted to a discussion of the social role of basic research and its relation to applied research and technology. The rapidity with which basic knowledge can be applied (consider the development of the transistor) also adds to the timeliness of this topic. Nor should the contribution of applied research to basic research be ignored (*9*). The need for reasonable financial support of basic research can thus be emphasized, and the students in their role as citizens may use their influence in support of an enlightened policy toward support of pure research by government and private agencies.

Undoubtedly, the most difficult of the general education goals to realize is the last one. To acquaint a student, even a science major, with the aesthetic appeal of science is an ambitious undertaking. But even though the student cannot be expected to achieve a real appreciation of this aspect of science, he should be aware that scientists are often moved by essentially nonrational and even artistic impulses. Why is a mathematical proof elegant? Why do we prefer a theory which is concise and employs only a few assumptions? What is the thrill of a new discovery? Science is a creative endeavor and the scientist a creator. This aspect of science is admirably treated by Sullivan (*10*).

Two years' experience with this approach indicates that this minimum amount of general education can be introduced into the general chemistry course without sacrificing "essential content." Whether the goals can be achieved with such limited class discussion is uncertain, but if the student can be aroused to augment class material with outside reading, the results can be most gratifying.

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A SIMPLE GAS-MIXER PUMP

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A SIMPLE gas-mixer pump was required for studies involving gas and vapor evolution in static reactor systems. A magnetically driven gas pump was developed featuring simple construction, operation, and servicing. The essential features of this pump and some performance data are given in the hope that other workers may find this type of pump useful.

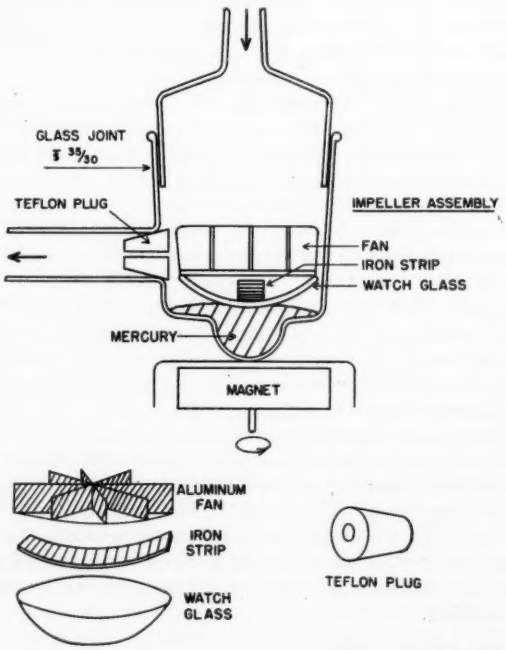

Figure 1. Gas-mixer Pump

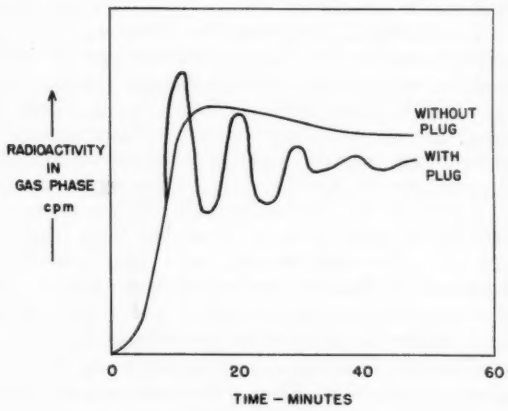

Figure 2. Gas-pump Performance Curves

Sketches of the pump are shown in Figure 1; the glass-joint housing makes for simple replacement or adjustment. The drive unit is a rectangular iron strip curved to fit against the watch glass and sealed from the gas atmosphere by the base plate of the aluminum fan unit. The fan blades were cut from sheet aluminum and cemented to the aluminum base plate with a sodium silicate-iron oxide cement; this cement was used for the entire gas-impeller system.

Some performance data are indicated in Figure 2. These data show the pumping behavior for a radioactive vapor admitted to a 130-ml., cyclic, static reactor system containing a Geiger-counter gas cell. An improved pump might be made from an impeller molded completely of "Teflon" tetrafluoroethylene resin containing an embedded bar magnet.

A LABORATORY EXERCISE IN CATALYTIC DEHYDROGENATION

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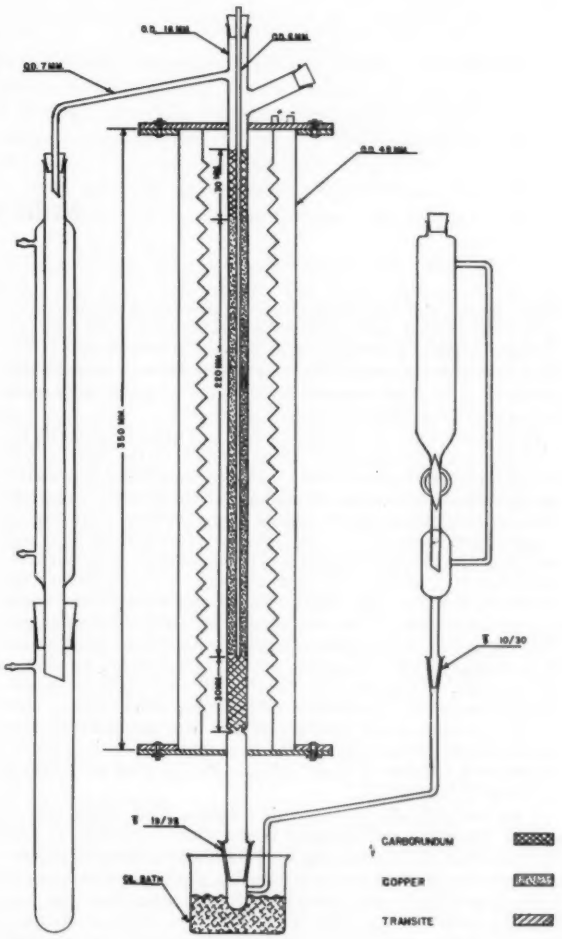
Although catalytic dehydrogenation of alcohols is a well known and important method for the preparation of aldehydes and ketones, no current laboratory manual to the authors' knowledge includes this type of reaction on a preparative scale. We have developed an apparatus of convenient size using an easily-prepared copper catalyst which gives good results in the hands of students, or which may be used as a demonstration.

Details of construction of the heating jacket and catalyst column are shown in the figure. Temperatures were measured with a pyrometer, but it is possible to use a 360° thermometer in which case the thermowell should be made large enough to accommodate it. This will necessitate a slightly larger-diameter column but the dimensions are in no way critical. The heating element was wound with No. 22 nichrome wire on a mandrel having a diameter of 3 mm. Four tightly-wound coils approximately 9 cm. long were prepared. These were stretched as they were mounted in the column and then connected in series. Temperature was controlled by means of a Variac.

We prepared the catalyst by filling the column with copper-oxide wire, preheating to 280°, and reducing in a slow current of hydrogen (two or three bubbles per second) at a temperature of 280° to 300°. Reduction required about five hours under these conditions but produced a very active catalyst. A catalyst of satisfactory activity can be prepared by preheating the column to 300° and reducing with a rapid flow of hydrogen so that the temperature in the zone of reduction reaches 400° to 450°. Reduction is complete in about one hour.

With the oil bath surrounding the flash boiler preheated to approximately 100° above the boiling point of the alcohol to be dehydrogenated, and the column at a temperature of 300° to 325°, the alcohol was allowed to flow into the boiler at a rate not exceeding one drop per second. Dehydrogenation of a 15-ml. charge required from one-half to one hour. Yields were determined by fractional distillation of the product, by collection and measurement of the hydrogen evolved (least reliable), by refractive index, or by titration using hydroxylamine hydrochloride with bromphenol-blue indicator. The same catalyst was used with somewhat decreasing efficiency for five or six successive runs. Fine-gage copper-oxide wire gave some trouble because of clogging; this difficulty was eliminated by the use of a coarser gage.

[1] Address correspondence to this author.



Distillation in an ordinary distilling flask or small fractionating column was adequate for purification of products where the boiling points of the alcohol and corresponding carbonyl compound were sufficiently far apart. Separation of cyclohexanol and cyclohexanone, however, was best accomplished by converting the cyclohexanone to the bisulfite addition compound. In a typical run 12 g. of 2-butanol was dehydrogenated over

the rapidly reduced catalyst. Simple distillation of the product gave 8.8 g. (73.5 per cent) of butanone boiling at 79° to 83° (corr.). The table lists results obtained with several alcohols over slowly reduced catalyst. All yields were determined by hydroxylamine-hydrochloride titration and the figures are composites of two or more runs.

Alcohol	*Yield of aldehyde or ketone (%)*
2-Propanol	92–98
1-Butanol	95
2-Methyl-1-propanol	90
2-Butanol	90–94
2-Pentanol	90
Cyclohexanol	90–94

NICE TIMING

MASS, length, and time are the basic variables in all physical processes. To describe such processes accurately, one must measure all three variables precisely and in terms of invariable standards. With new techniques of chronometry, scientists can measure the timing of natural phenomena with an accuracy far surpassing that of man's traditional timepiece—the earth.

To measure time, it must be divided into suitable intervals by some repetitive process, such as the rotation of the earth about its axis (man's first unit of time). Also, one must be able to count the repetition, for example, by marking off the days on a calendar. More precise measurements require periodic effects occurring at a more rapid rate, e.g., a clock pendulum oscillating once per second, or the quartz crystal of a radio transmitter vibrating millions of times a second. Even such devices are not reliable time standards, however; the length of a pendulum or the thickness of a quartz crystal can be machined to only a limited accuracy. The dimensions of materials change—hence timing devices lose their accuracy—with changing external temperature, humidity, and pressure. Thus, the oscillations of such devices must be corrected occasionally by means of astronomical observations. Although a well-designed quartz oscillator can maintain its frequency to one part in 100 million for an hour or two, it is nevertheless only a means of finely subdividing the time we measure by the earth's rotation.

A further difficulty is that this rotation itself is not steady enough for some astronomical observations. Because of the frictional drag of the tides, and for other reasons, the earth is slowing down, and our second—defined as $^1/_{86,400}$ of a mean solar day—is slowly getting longer. Another difficulty arises from the fact that the earth is a liquid contained in a more or less solid crust. Relative motion between the crust and the interior, and possible redistribution of matter in the crust itself, cause the length of the day to vary. Compared to an initially synchronized absolute clock, the earth's time may change by as much as one and a quarter seconds per year. This kind of deviation shows up in astronomical observations as an apparent unevenness in the motion of the moon and planets relative to the earth.

The ideal way to overcome such difficulties is to rely on a time standard that has some fundamental relation to the structure of the universe. Thus, even the best man-made pendulums and quartz crystals are ruled out, and scientists have sought invariable and reproducible periodic phenomena within matter itself. Recently, the National Bureau of Standards developed an atomic clock based on the internal vibrations of atoms within molecules. These vibrations, unlike those of pendulums or crystals, are largely uninfluenced by external conditions, and are independent of the earth's rotation. Usually atomic vibrations are of the order of a billion megacycles per second, too rapid to be counted, but two circumstances have recently made counting possible. First, progress in electronics now permits counting circuits to be operated at frequencies of 20,000 to 100,000 megacycles per second. Also, some molecules and atoms have been discovered that naturally vibrate at just these relatively lower "microwave" frequencies.

AMMONIA CLOCK

The first counting of molecular vibrations was done with ammonia molecules, which are built like triangular-based pyramids, with three hydrogen atoms at the corners of the base and a nitrogen atom at the top. The nitrogen atom vibrates toward and away from the base, and occasionally passes through the base to a position on the other side. When radio waves are transmitted through a tube filled with ammonia gas, this inversion occurs more frequently if the radio waves have exactly the microwave frequency at which the nitrogen atoms are vibrating. Energy is absorbed in the process; the energy of the radio waves is measured after they have passed through the tube, and maximum energy is absorbed if the whole system is precisely in tune.

The ammonia clock runs with a constancy of one part in 50 million, and may be improved to one part in 100 million or more, considerably better than the accuracy of the earth's rotation. A further refinement of technique uses a beam of ammonia molecules; here the fuzziness due to molecular collisions in a gas is overcome. In this case, the heated molecules themselves emit a microwave signal, which is detected and used as the time standard.

Another type of clock under development at the Bureau may be controlled by the magnetic behavior of cesium atoms. Here the vibration is caused by applied magnetic forces acting upon the atom; since the cesium atoms are not free to collide with each other as do the molecules in the ammonia clock, the frequency of the vibration can be measured about 300 times more precisely, to an accuracy of one second in 300 years, 400 times better than that of the earth.

With such a clock, it should be possible to study a number of problems of great scientific and practical importance, ranging from changes in the earth's rotation and checks on the theory of relativity to improvements in navigation. Also, atomic time may eventually come to be recognized as the international standard, for scientific purposes. For one thing, it is universal, and would hold good if we should ever colonize Mars. But the earth-bound work will continue from sun to sun, under the stimulus of the seasons.—*Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.*

THE EASTERN COLLEGES SCIENCE CONFERENCE

An Example of Undergraduate Interscience Cooperation[1]

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A UNIQUE and worthy example of undergraduate enterprise is the Eastern Colleges Science Conference, now in its ninth year. This venture has not attracted, outside the immediate circle of its clients, the publicity which it deserves and which it needs to assure continued growth and success. In view of this, it seems appropriate to present, in the light of our own recent experience as host, a brief summary of its progress to date, its future problems, and ways in which college chemistry instructors can both help and utilize the conference to the profit of their students.

The conference was organized at Vassar in 1947 by a group of 105 students from 23 Eastern colleges. A constitution was drafted, which prescribed the structure and method of operation which have prevailed ever since. The stated purpose of the conference is the stimulation of undergraduate interest in the natural sciences and their relation to other fields. This is accomplished by means most familiar to American Chemical Society members: the holding of an annual two-day meeting, with technical sessions featuring contributed undergraduate research and library papers, general sessions addressed by eminent scientists, tours of nearby industrial and academic installations, and, not least, the various elements of sociability, formal and informal, which make any scientific convention a vital organism. The permanent secretary of the conference is the *Yale Scientific Magazine*, but its responsibility is limited to the keeping of suitable records and the annual publication of an article describing the conference for that year. All other duties devolve upon the host college for the year, which decides the date and program for the conference and arranges publicity. The only obligatory features of the conference are the presentation of papers representing the original work of undergraduates, and a business meeting. The entire affair is undergraduate-managed, with the faculty playing a purely advisory role. Each participating college may appoint two delegates to represent it at the business meeting.

Features of the eight conferences held to date are summarized in the table. Chemistry papers make up about one-third of all those presented. The quality has been high, the topics most varied. Examples are: "The application of pyridine-borine in the determination of iron," "The chemistry of allonphanates," "The study of distribution coefficients using radioactive isotopes," and "Chromatographic identification of the sugars in the acid hydrolyzate from the eggs of the leopard frog, *Rana Pipiens*." Prominent chemists who have served as invited speakers are Nicholas D. Cheronis, Paul Emmett, Louis Fieser, Joseph Fruton, Raymond E. Kirk, and W. A. Noyes.

Who comes, or who should come to the Eastern Colleges Science Conference? The registrants are primarily undergraduate students, with men predominating. Less than 10 per cent of the registrants are faculty and their families, and most of these come for the sake of their students. It is the undergraduates for whom the conference is a highlight of the academic year, and it is they who should be encouraged to attend in larger numbers. Although large universities such as Princeton and Yale have generally been represented, as well as West Point and Annapolis, the smaller liberal-arts colleges have been the backbone of the enterprise and profit from it the most, both socially and intellectually. Thus, small groups from such colleges have journeyed over 500 miles to attend the conference, and have almost always departed in an obvious glow of enthusiasm. Some colleges are able to subsidize the students and faculty members attending, in whole or in part, but this is far from being a universal practice.

The optimum number of registrants may be estimated at about 500, wherever local housing facilities permit. With the present, satisfactory two-day timetable, the total number of undergraduate papers must be kept within bounds by careful selection. However, a conference tenanted only by paper-givers would be a failure from the financial and social viewpoints, and would not draw a suitable caliber of invited speakers. Therefore, passive participants are welcomed and encouraged to attend insofar as housing and eating facilities permit. To maintain suitable registration levels requires continued and active participation of from 70 to 90 institutions.

The major continuing problems which such a conference faces are stability, communication between host and participants, financing, and entertainment. Financing involves the receipt and expenditure of about $4000 and must be done with the undergraduate pocketbook in mind. The management of such sums is, of course, a most valuable business experience for the students di-

[1] Presented before the Division of Chemical Education at the 126th Meeting of the American Chemical Society, New York, September, 1954.

Date	Host	Number of registrants	Number of colleges	Number of undergraduate papers
1947	Vassar College, Poughkeepsie, N. Y.	105	23	No data
1948	Union College, Schenectady, N. Y.	159	26	No data
1949	Adelphi College, Garden City, N. Y.	285	43	No data
1950	Barnard College, New York City	567	90	63 of 20 minutes, 25 (40%) in chemistry
1951	Yale University, New Haven, Conn.	466	80	55 of 30 minutes, 16 (29%) in chemistry
1952	Pennsylvania College for Women, Pittsburgh, Pa.	397	82	73 of 30 minutes, 22 (30%) in chemistry
1953	New York State College for Teachers, Albany, N. Y.	340	85	60 of 30 minutes, 17 (29%) in chemistry
1954	Brooklyn College, Brooklyn, N. Y.	375	67	68 of 30 minutes, 24 (35%) in chemistry
1955	Seton Hall University, South Orange, N. J.[a]			

[a] Address inquiries to Mr. Roy Failla, Chairman, or to Professor Daniel St. Rossy, Faculty Adviser.

rectly involved. The host college is responsible for any deficit. However, any profit goes into a revolving fund which is transmitted from one host to the next to provide a cushion, and now amounts to about $500. As for entertainment, the conference will be improved when more of the participating colleges are willing to assume the obligation of host, and when the locale changes from year to year instead of being so closely confined to the region about metropolitan New York. Our experience at Brooklyn shows that playing host to the conference is one of the finest educational experiences that can come to the students who take part, and one that will give an uplift to all the science clubs on the campus.

What can college teachers who read this article do to promote this worthy enterprise? For those in the Northeast there are at least four specific ways to help. In the early fall you can plan undergraduate research projects for presentation at the conference, which normally meets in late March or April. You can stir up interest in a group of top chemistry majors, and attempt to secure a subsidy for their attendance. You can pass on promptly and to good advantage any publicity literature received from the conference. You can endeavor to get the science faculty and student body sufficiently interested to present a bid to serve as host. For your efforts you will be well repaid. Those who live outside the Northeast might well consider planting the seeds for similar regional enterprises elsewhere.

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

MEETING OF THE NORTHERN SECTION

At a meeting of the Pacific Southwest Association of Chemistry Teachers, Northern Section, held in Davis, California, November 6, 1954, a symposium was conducted on The Teaching of Organic Chemistry. Addresses were presented by three representatives of northern-California colleges.

Peter Coad, College of San Mateo, in a discussion of the mooted topic "Organization of the short course in organic chemistry," described a short course for the first semester, accommodating both chemistry majors and students of applied life sciences. A second-semester course was primarily for chemistry majors. Even in the short course, the speaker observed:

> I used synthetic problems as a tool for stimulating interest as well as to aid in developing reasoning power. I omitted from my short course all but the slightest mention of dye chemistry, carbohydrates, degradations, name reactions for the sake of learning attractive names, and polymers. I also omitted any special preparations of compounds which were not general for a homologous series of compounds.
>
> Whenever feasible I gave different problem sets to chemistry majors, to premedical majors, and to those in other categories, in order to increase the interest and experience of the individuals involved. In fact, occasionally two alternate lectures were given for chemists and premedical students; the others in the class selected the lecture for which they would be held responsible on the test that followed.

Arthur Furst, Stanford University School of Medicine, discussed the topic, "Concepts and techniques in teaching the organic-chemistry laboratories." Emphasis was placed on the majority opinion of teachers of organic chemistry as to the main purpose of the laboratory. The speaker observed:

> The majority of instructors feel that the main, if not the only function of a laboratory is to illustrate by example what is presented in the lectures. This view, at least, is held by textbook writers at a ratio of four to one. The main concern of this group is the correlation of lecture and laboratory materials. Timing is of the essence, for, although it takes a few moments for the instructor to mention that ethyl alcohol can be obtained by fer-

mentation, a number of laboratory periods are required by the student to prove it.

A second, but much smaller group of organic laboratory instructors feels that the organic laboratory must have for its major objective an introduction to the physical-chemical concepts underlying the theory of separation and purification. One word of caution, however, on such a program: It is very easy to lose sight of the main purpose of the course and to convert it into a physical-chemical course, albeit a miniature one. Although it is important that the students get a good qualitative picture of constant-boiling mixtures, melting-point curves, etc., they must not be "snowed under" by the mathematics involved.

Perhaps the well-rounded course should have several major objectives rather than one. It therefore need not follow closely any set of lectures notes, but will contain experiments to illustrate only a selected number of reactions and laboratory procedures. Part of the laboratory time can be devoted to a discussion to help the student to understand the reasons and theory behind the laboratory work.

In addition to desirable attention to standard safety regulations in the laboratory, the speaker observed that special attention may well be called, during a laboratory session, to shortcomings of current operations. For example:

In cases of very poorly constructed apparatus, it is sometimes necessary to ask the student to tear the entire thing down and then rebuild it. The psychological effect on the class is interesting. It is also necessary to remind students that a fire hazard is involved *after* a distillation or fractionation is completed. For some unknown reason, students are prone to remove the thermometer from the hot fractionating column or distilling flask as soon as the run is over (and some immediately cool the thermometer under the tap).

Continuing discussion of the value of emphasizing introductory physicochemical concepts, the speaker observed:

From the vapor-pressure temperature curve the various concepts can be illustrated, and the normal distillation and fractionation curves can be drawn. Statements can be made about the escaping tendency of pure solvents, which can be modified by the solutes so that it is possible to have a maximum as well as a minimum boiling point. From the lower part of the vapor-pressure temperature curve the behavior of solids can be discussed. Minimum and maximum melting points of mixtures can also be included. Simple experiments can be conducted, such as distilling a mixture of liquids and then fractionating it. From a plot of volume of the distillate versus temperature, and construction of both curves on the same piece of graph paper, comparisons can be made. Cooperative experiments can also be worked out. Each student can be asked to take the melting point of two pure substances, and then the melting range of an assigned mixture of those two compounds. These values can be recorded on a convenient spot on the blackboard or bulletin board. When the entire range of concentrations has been covered, these data can be used to construct graphs. This serves as an excellent basis for the discussion of melting-point curves.

Dissatisfaction was expressed with treatment of the balancing of equations in current laboratory manuals, particularly with the "valence-change" method:

It is rather surprising that no laboratory manual has a good treatment of this subject. Granted that no scheme is really better than any other, it is still helpful for the student to learn a method that he can apply to organic as well as inorganic chemistry. There is no doubt that the use of [O] or [H] is quite simple; it is not necessarily, however, more helpful to the student. The valence-change method is really misleading. Hence, the method of half-reactions should be that of choice. Parenthetically, there is no reason to balance equations other than for calculation of yields.

Grading of students, according to Furst, solely on examinations is only too common, and to be deplored:

Laboratory work should represent a definite percentage of a student's grade. It is not necessary to grade every experiment, just as it is not necessary to grade every problem set. The tendency to grade upon yields alone, however, is not a wise one. Students soon learn that there are two ways to increase yields.

Dr. Donald S. Noyce, University of California, Berkeley, discussing "Trends in the teaching of organic chemistry," pointed the way toward modernization, particularly from the standpoint of physical concepts. Instead of assuming organic chemistry to be—in the words of Wöhler—"a primeval forest, full of the most remarkable things, a monstrous and boundless thicket," the speaker and his Berkeley colleagues start with the background of ions and rapid, quantitative reactions. One proceeds next to a careful explanation of the principles of the covalent bond, and its effects as interpreted in reaction rate and in terms of possible competitive reactions. Noyce continued:

The principles of the early part of the course are the covalent bond, the electron pair, the atomic orbitals used in bonding such as the *s* orbital, and the resulting sigma bond. Nomenclature is emphasized during discussion of alcohols and hydrocarbons. Principles of bond polarization, the displacement reaction, and the effect of conditions of the directions of reaction are presented and illustrated with the reactions of alkyl halides.

Molecular geometry comes up for further treatment with the alkenes, and the *p* orbitals and the pi bond are discussed and used. The first presentation of resonance is with the carboxylic acids and the carboxylate ion, when reasons for the acidity of acetic acid are discussed. Again the pi orbitals available for the distribution of the charge are used.

The speaker stressed difficulties in choice of material:

Take the situation with respect to aldehydes. The preparation of aldehydes is, by the very nature of the reactivity of the functional group, a difficult process. Reflecting this is the continuing search of many workers for ways of making aldehydes. An encyclopedia of aldehyde preparations can easily be prepared; it can easily be presented. But it will also easily swamp the student with such a vast amount of material that he will be unable to absorb much, let alone evaluate any of it. Hence, I include only a very few selected reactions, chosen for generality of success and for illustration of important characteristics of the types of compound from which aldehydes are prepared. The Rosenmund reduction of the acid chloride might be used, for example; it illustrates the necessity for careful choice of experimental conditions, it works well, and it shows the problem of avoiding competing reactions.

In terms of basic chemical training the emphasis is on the principles of the behavior of organic compounds, and the attempt is made to develop a rational system for predicting the behavior of new classes and types of organic systems.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

OFFICIAL BUSINESS

277th MEETING

The 277th meeting of the NEACT was held at New Hampton School for Boys, New Hampton, New Hampshire, October 9, 1954. There were 46 members and guests in attendance. Mr. Frederick Smith, Headmaster of New Hampton School, cordially extended the hospitality of the school to the Association.

The first speaker was Dr. Alan Lukens, Lukens Laboratories in Newton, Massachusetts, whose topic was "Organic coatings." He gave a very interesting and informative address on fine grinding of materials and the application to the paint and pigment industry.

Dr. Walter J. Gensler, associate professor of chemistry at Boston University, next spoke on "Recent developments in organic chemistry." Some of the subjects discussed were: carbon-14 to determine the approximate age of prehistoric plant growth; petroleum as a raw material for manufacturing various organic compounds such as acetic acid, and of some synthetic fibers; synthesis of sucrose, morphine, and strychnine; work being done on Aureomycin and Terramycin.

A delicious luncheon was served in Berry Hall, after which a short business meeting was conducted by John A. Timm, president of the Association.

The third speaker was Mr. Horace A. Sherman of the physics department at St. Paul's School, whose subject was "Industrial rambles through the South and West." He and Mrs. Sherman spent several months last spring and summer traveling through the United States, Mexico, and Canada, and visited a number of industrial plants during their trip. He showed a number of beautiful colored slides and spoke about industrial developments that he witnessed.

At the business meeting, President Timm read a letter from Carl and Natalie Swinnerton who are on leave from the Pomfret School. Carl sent greetings as an alumnus and member of the Board of Directors of the New Hampton School.

President Timm also read a letter from Dr. David L. Davidson in which was enclosed $25 for a scholarship for a high-school teacher to attend the Seventeenth Summer Conference at Tufts College.

The secretary welcomed the following new members into the Association:

J. F. Flanagan, S.J., Chemistry Instructor, Boston College High School, Boston, Massachusetts.

Walter J. Gensler, Associate Professor, Boston University, Boston, Massachusetts.

Sidney Kaplis, Teacher of Chemistry, Harding High School, Bridgeport, Connecticut.

A vote of thanks to the New Hampton School for the hospitality of the day was taken with enthusiasm.

278th MEETING

On December 4, 1954, the 278th meeting of the Association was held jointly with the New England Biological Association and the Eastern Association of Physics Teachers at Wentworth Institute, Boston, Massachusetts, which is celebrating its fiftieth anniversary. Before the meeting members were taken on conducted tours through the school laboratories. The attendance was even larger than usual.

Mr. H. Russell Beatty, president of Wentworth Institute, in describing the technical training offered by his school, pointed out that while there has been an increasing emphasis on engineering courses recently the number of engineering technicians being trained does not nearly meet the demand of industry, and that this year the Soviet Union will graduate between four and five times as many as we do. There is need for two or three technicians for every graduate engineer.

The American Academy of Arts and Sciences, represented by Professor Sanborn C. Brown, of Massachusetts Institute of Technology, presented to five New England science teachers awards of $100 each and a citation "for outstanding teaching in science and mathematics." The recipients were Eleanor E. Taylor, Central Junior High School, Quincy, Massachusetts; Norman W. Lafayette, Hamden High School, Hamden, Connecticut; Wallace W. Sawyer, Weston High School, Weston, Massachusetts; Howard Wagner, High School, Laconia, New Hampshire; and Maurice Whitten, High School, Lewiston, Maine. Three are NEACT members.

Mr. Wayne McRae of Ionics, Inc., Cambridge, Massachusetts, speaking on the problem of increasing our future water supplies, described the energy requirements of the various proposed ways to purify water, the relative desirability of these systems, and a new method being investigated which uses permionic membranes to demineralize water.

A vivid illustrated talk was given by Dr. Harold E. Edgerton, of Massachusetts Institute of Technology, who has recently done some exploring in the waters of

the Mediterranean *via* a bathyscape and aqualung in an attempt to learn more about the puzzle of the deep scattering layer and of life under the water. His camera, equipped with high-energy flash lights, brought up unusual pictures of objects in the sea and surface pictures of objects raised from ancient sunken vessels.

The afternoon speaker, Dr. Lockhart B. Rogers, of Massachusetts Institute of Technology, pointed out that the field of atomic-energy research, with its emphasis on trace amounts of materials, has recreated a demand for analytical chemists. In describing how the analyst uses coulometry, polarography, and spectrometry, he also demonstrated relatively simple equipment teachers can construct in their laboratories for making quite accurate measurements in these fields, to teach basic principles.

The business meeting was called to order at 1:50 P.M. by President John A. Timm.

Two new members joining at the Sixteenth Summer Conference and not previously recorded, were welcomed into the Association by the secretary:

Ward M. Hunting, Assistant Professor of Chemistry, Eastern Nazarene College, Wollaston, Massachusetts.
George H. Sloan, Head of Science Department, Rutland High School, Rutland, Vermont.

The following new members joining since the October meeting were also welcomed into the Association:

George A. Consolazio, Nucleonics Branch, Watertown Arsenal Laboratory, Watertown, Massachusetts.
David M. Howell, Assistant Professor of Chemistry, Northeastern University, Boston, Massachusetts.
Arnold E. Levitt, Instructor in Chemistry, University of Massachusetts, Amherst, Massachusetts.
William B. McIlwaine, Chemistry Teacher, B.M.C. Durfee High School, Fall River, Massachusetts.
Carl E. Medde, Instructor, Bradford Durfee Technical Institute, Fall River, Massachusetts.
Sister Mary Viviana, Science Teacher, Mission High School, Roxbury, Massachusetts.
Richard M. Strawcutter, Chemistry Teacher, Greenwich High School, Greenwich, Connecticut.
Henry R. Trespass, Chemistry Teacher, Technical High School, Springfield, Massachusetts.
Arthur J. West II, Instructor in Biology, Suffolk University, Boston, Massachusetts.

The president reported that the Northeastern Section of the American Chemical Society will give *Lyman Newell grants* to five teachers to attend the Seventeenth Summer Conference; in addition, the Maine Section will send two teachers, and other New England local sections are still considering the proposal to sponsor high-school teachers in their respective areas.

A vote of thanks to Wentworth Institute for the hospitality of the day was taken.

17th SUMMER CONFERENCE

The Executive Committee voted last summer to accept the invitation to hold the next summer conference at Tufts College, Medford, Massachusetts. This shift from the usual rural scene to an urban one is an experiment that will make it possible to take advantage of the many educational, cultural, industrial, and historical aspects of greater Boston. It is planned to visit the Saugus site of the first blast furnace and iron foundry in America. This was recently restored at a cost of $1,500,000 by the American steel industry. Families are welcomed to the Conference and tours and recreational opportunities in the Boston area are being scheduled for those who do not wish to attend the technical sessions. A special program for teen-age youngsters will be organized.

The program includes discussions of chemistry and dental caries, components of poison ivy, ultrasonics in chemistry, new methods of sterilizing and preserving food, and the following educational subjects: historical approach to the teaching of chemistry, chemical industry and employment of chemists, quantitative aspects of laboratory teaching, construction and uses of crystal models. Other papers are being arranged.

The following have been appointed to serve as the committee for the Seventeenth Summer Conference:

Officers

John A. Timm, *President of NEACT*, Simmons College, Boston, Massachusetts.
Roland M. Whittaker, *Co-chairman*, Queens College, Flushing, New York.
Angela M. Trovato, *Co-chairman*, Robinson Seminary, Exeter, New Hampshire.
Robert D. Eddy, *Secretary*, Tufts College, Medford, Massachusetts.
Clarence D. L. Ropp, *Registrar–Treasurer*, University of Bridgeport, Bridgeport, Connecticut; *Assistants*, Mrs. Ropp, Mrs. Phyllis Brauner, Simmons College

Committees

Exhibits. Thomas R. P. Gibb, Jr., Tufts College, *Chairman;* Edward M. Collins, Denison University, Granville, Ohio.
Hospitality. Paul R. Doe, Spaulding High School, Rochester, New Hampshire, *Chairman.*
Motion Pictures. Charles E. Walkden, Barrington High School, Barrington, Rhode Island, *Chairman.*
Printing and Mailing. Russell W. Bennett, Fisher Scientific Company, Cambridge, Massachusetts, *Chairman.*
Publicity. Laurence S. Foster, Watertown Arsenal Laboratory, Watertown, Massachusetts, *Chairman;* David L. Davidson, Marguerite Houlihan.
Social Events. Ida B. Routh, Bryant High School, Long Island City, New York, *Chairman;* Mrs. Alice Howe, Windsor High School, Windsor, Vermont; Ruth Lindquist, Lasell Junior College, Auburndale, Massachusetts; R. D. Cool, Madison College, Harrisonburg, Virginia.
Excursion and Dinner. Raymond E. Neal, Simmons College, *Chairman;* Louise C. Swenson, English High School, Lynn, Massachusetts.
Guest Activities. Mrs. Laurence S. Foster, 16 West Street, Belmont, Massachusetts, *Chairman.*
Teen-age Activities. Francis M. Lamoureux, Palmer High School, Palmer, Massachusetts, *Chairman.*

Inquiries should be addressed to the conference secretary, Professor Robert D. Eddy, Tufts College, Medford 55, Massachusetts.

LEALLYN B. CLAPP
Secretary

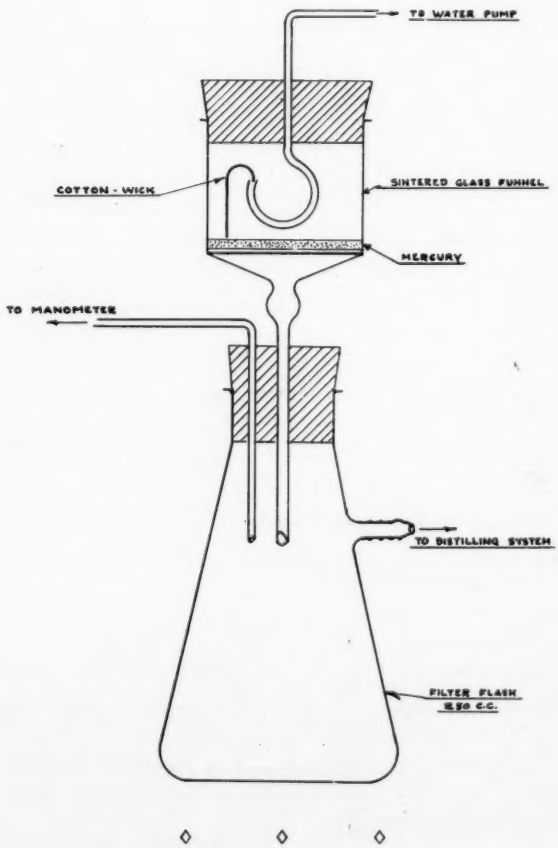
DEVICE TO PREVENT BACK-SUCTION IN VACUUM SYSTEMS

G. P. MATHUR AND S. MUKHERJEE
Indian Institute of Sugar Technology,
Kanpur, India

THE apparatus shown in the illustration is useful in preventing back-suction in vacuum systems such as reduced-pressure distillations. The mercury layer in the funnel acts as a valve, permitting air to bubble through under suction but preventing water or air from entering the system if the pump fails, as occasionally happens. The "cotton wick" shown in the funnel is not essential, but it helps to keep the mercury surface free from water.

A simpler but perhaps less satisfactory "valve" was described recently by Chaco (J. CHEM. EDUC., **31**, 547 (1954)).

The authors thank Professor J M. Saha, Director, for his interest.



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To the Editor:

When is prediction prediction? "Prediction of thermodynamic data—a problem in chemical engineering" is the title of an article (J. CHEM. EDUC., **31**, 641 (1954)) by James H. Weber. Do chemical engineers really predict—as prophets predict? And do their predictions come true? Do chemists predict? Or does everybody predict?

Chemical engineers have to make do with woefully inadequate data in most of the problems they have to handle practically. When the pertinent data are not available, they estimate them, with as much reliability as they can, from less pertinent data. They are sometimes able to do this remarkably well from extremely remote data—but not, of course, from no data at all. How remote do the data have to be for this process of estimation to be called *prediction*?

Often, when the latent heat of vaporization of a liquid is required, it is found that this has never been the subject of a direct determination. But it may often be found that the vapor pressure of the liquid has been determined at a number or temperatures. It is then a simple matter to calculate the latent heat of vaporization by means of the Clapeyron-Clausius equation. The physical chemist calls this "indirect determination"; many of his determinations are of this kind. The chemical engineer calls it "prediction."

Suppose the solubility of a substance at 80°C. were needed, but the only published determinations were at 10°, 20°, 30°, etc., up to 70°C. If the published data lay on a smooth curve, extrapolation to 80°C. would be extremely simple. Would it be prediction?

What about interpolation? If the solubility at 25° were required, no one would have any difficulty in estimating it. This sort of thing is done all the time by all scientists, and nobody thinks of it as a kind of prophecy.

The more remarkable achievements of the chemical engineer involve the estimation of the data they require from other data related more remotely than are the vapor pressure and the latent heat. Practical chemical engineers are sometimes able to make very plausible estimations from no data at all on the compound in question, provided they have data on compounds bearing some similarity to it. But even this need in-

volve nothing more intellectually surprising than indirect determination or extra- or interpolation. Suppose, for a series of homologous hydrocarbons, very accurate determinations had been made of the heat of combustion of the members C_n, C_{n+1}, C_{n+2}, C_{n+4}, C_{n+5}, and C_{n+6}—undoubtedly by Dr. F. D. Rossini—but suppose that for some reason the member C_{n+3} was not available. Some chemist now synthesizes C_{n+3}. For its heat of combustion, all he has to do is to plot Dr. Rossini's data against n, and estimate (or "predict") it for the new compound with a considerable degree of certainty. True, most cases of chemical engineering prediction are considerably more remote than this, but the mass of scientific data now available forms such an interconnected web that although the result may be more surprising, the principle is the same.

So who predicts?

Turning the matter around and looking at it another way, any scientist predicts, whenever he makes use of any scientific generalization to indicate the probable result of a proposed experiment. If I put ten grams of a substance into 100 g. of water at 25°C., and if I know that the solubility at 25° is eight grams per 100 g. water, then I can predict that two grams will remain undissolved. If I hold my pencil over my desk, I can use the law of gravitation to predict that it will fall to the desk when I release it.

One more turn. I live after Newton, and I can invoke his great name, and his famous law, as I poise my pencil over my desk. But if I had lived *before* Newton, I could have made the same prediction with the same degree of certainty, for I would have been very well aware that a stylus (or whatever they used) would fall downward if unsupported. And so it seems that prediction does not require scientific knowledge of any kind.

Conclusion: Anybody predicts, and we all do it all the time. Or else nobody predicts, except a prophet (or a pollster). Chemical engineers have developed to a high state the art of *estimation* or *indirect calculation*, but to call what they do "prediction" is inappropriate, because the word is of such vague significance that its application here is either (*a*) untrue, or (*b*) of such wide significance as to be meaningless.

ANTHONY STANDEN

INTERSCIENCE ENCYCLOPEDIA, INC.
BROOKLYN, NEW YORK

To the Editor:

For a number of years I have been a faithful follower of the many interesting brain-teasers put forth by Professor Julius Sumner Miller, a man who can successfully confuse the disarmingly simple with the fiendishly ingenious. Recently, Professor Miller propounded a query in this column (J. CHEM. EDUC., **31**, 667 (1954)) concerning the preservation of pencil erasers with para-dichlorobenzene mothballs. It appears that the primary preservation process is simply one of air displacement by the heavy vapors of the mothballs. Presumably, this is the same process that prevents moths from living and breeding in such an atmosphere—the lack of oxygen. At the bottom of the trunk there would be practically no convection currents and thus no back diffusion of oxygen from the air.

I doubt if the action is a chemical one, since para-dichlorobenzene is not the sort of compound used as a rubber antioxidant. However, had the erasers been in direct contact with this substance they probably would have been swollen and decomposed by the solvent action toward rubber typical of chlorinated hydrocarbons in general. In the future, it would seem the safest course for Professor Miller to use carbon dioxide as his eraser preservative. This gas is sufficiently dense for back diffusion to be negligible in a moderately well sealed trunk.

JUDSON L. IHRIG

UNIVERSITY OF HAWAII
HONOLULU, HAWAII

To the Editor:

All teachers who use objective tests and grade in a statistically correct manner are familiar with the anguished cries of students who think they are being treated unfairly. It is usually possible to show the logic involved in subtracting the number of wrong answers from the number of right answers in ordinary true or false tests, but in more complex multiple-choice types the students' self-interest arguments are rather difficult to answer simply. ("Why do I have to have twelve correct answers before I get any grade at all?") In questions like the following the instructor can always look forward to a battle if he uses statistically correct grading.

Put the letter corresponding to the correct matching word or expression in front of each of the following statements. A given letter may be needed once, more than once, or not at all.

Key

A. Nitrogen *B*. Oxygen *C*. Water vapor *D*. Neon *E*. None of these

—1. The concentration of this substance in the atmosphere varies greatly.
—2. This substance is not present in the atmosphere.
—3. This substance can be liquefied at room temperature.
—4. Over three-quarters of the atmosphere consists of this substance.
—5. Only traces of this substance are present in humid air.
—6. This substance makes up about one-fifth of the atmosphere.

Circle the letters at the left which correspond to correct statements. Any number of parts in each question may be correct, from none to four.

1. (*a*) (*b*) (*c*) (*d*) Boyle's Law (*a*) is a direct proportion, (*b*)

relates gas volume and gas temperature, (*c*) predicts that if one writes a letter with a partly filled fountain pen in an ascending airplane, the pen will leak, (*d*) predicts that as a specimen of gas is allowed to expand at constant temperature, its pressure will decrease.

The writer recently hit upon another approach to this problem which seems to answer student criticism in a more direct, understandable manner. Just prior to the test, examination papers are handed out to a few of the students with the questions cut out, but with the places to circle letters, or fill in letters, remaining. Those having such papers take a minute or two to circle letters, etc., in any manner they choose. These papers now determine the number of errors corresponding to a zero grade, since the answers are a purely random selection such as anyone would make who knows no chemistry whatsoever. If papers so marked show, say, 50 errors, then it is established that this number corresponds to a zero grade, and each error is hence equivalent to two percentage points. The students taking the test are then reconciled to the fact that two points will be subtracted for each error they make.

This process, whereby the students themselves determine the basis for grading the test, seems to add to the interest, and diminish the number of arguments, when objective tests are used in the writer's own classes.

V. R. DAMERELL

WESTERN RESERVE UNIVERSITY
CLEVELAND, OHIO

• EXPERIMENTAL INORGANIC CHEMISTRY

W. G. Palmer, **Fellow of St. John's College, Cambridge, England. Cambridge University Press, New York, 1954. xx + 578 pp. 141 figs. 89 tables. 14 × 22.5 cm. $9.**

THIS is a somewhat old-fashioned book, profiting far more however, from the only too frequently neglected old-fashioned virtues than it suffers from lack of the very latest point of view. It is no mere collection of procedures from the literature, since the author has "personally carried out in [his] own laboratory every preparation and analysis in the book," making changes and improvements so that many of the "methods recommended in the text depart substantially from the older [literature] procedure." That all of these procedures have been examined in painstaking detail is evident both from the individual preparations and from the excellent discussion of general laboratory procedures in the introduction.

The aim of the author is to combat the "dull, monotonous, . . .burdensome drudgery" associated in students' minds with inorganic chemistry, by providing a text that will knit together the theoretical inorganic chemistry of the classroom with the practical inorganic chemistry of the laboratory, and to present it in a manner designed to interest the student. The rather sketchy theoretical discussions interspersed throughout the book are "intended to induce rather than render unnecessary the frequent consultation of modern textbooks of inorganic chemistry which [the author hopes] will be inspired by the bench work."

The author has attempted to give an understanding of the philosophy of inorganic chemistry by the careful selection of representative compounds, shown in their periodic relationships to one another. This aim in the main has been well achieved, but unfortunately in part has been defeated by adherence to the archaic convention of considering manganese with the halogens, chromium and molybdenum with the chalcogens, and so forth, when they could much more instructively have been considered as an integral part of the transition series. On the other hand, the surveys of the valencies of vanadium, molybdenum, and manganese are among the most instructive exercises possible.

The book also falls somewhat short of its aim because of the author's too zealous attention to making "no exacting demands upon expensive glassware." The author himself admits in the preface that as a result of this "the manipulation and preparation of compounds gaseous at normal pressures play a very small part in the book," and the same may be said of volatile compounds in general. A further result of this policy is that the preparations are carried out almost entirely in aqueous solution or occasionally in the most common organic solvents or high-temperature melts. Thus, the great wealth of illustrative chemistry available in such solvents as liquid ammonia, for example, has been entirely sacrificed. Likewise, the class of addition compounds is not represented. It is a great credit to the author, therefore, that, having limited himself almost entirely to aqueous solutions, he has succeeded in giving such a wide variety of preparations with so little duplication of method. The inclusion of several electrolytic preparations and the preparation of one clathrate compound are particularly to be commended.

Not the least of the book's virtues is the insistence on analysis in identification of products. In a field where the mixed melting point and the various other devices of qualitative organic analysis so frequently fail, this is a point of great importance, though one often neglected, presumably because of its lack of glamor. However, the author points out that "in analyzing the compounds they themselves have prepared [the students] find no drudgery."

Since this does not purport to be a book of theory, perhaps not too much should be said on this point. However, the presentation does have certain inadequacies in detail which detract from the generally pleasing picture, such as the uncritical acceptance of unequal bond lengths in the perchlorate ion (p. 436) and of the nonexistence of manganese carbonyls (p. 497). Some confusion is also evident in the citation of ionic character in P—O and Si—O bonds to explain wide bond angles, while in the same table are included phosphorus and arsenic trifluorides whose bonds surely have more ionic character and which nevertheless have smaller angles (p. 447).

Nevertheless, the reviewer feels that this book does help to answer a serious need. Within the limits to which the author has confined himself the coverage is excellent. The text is of par-

ticular clarity of organization and exposition. The index could have been improved by including certain intermediates of interest that do not appear in the section headings, such as sulfur monobromide and anhydrous stannous chloride. The diagrams, printing, and paper are good. The binding, however, is too light for a book that will inevitably have as much use as this one.

A. F. CLIFFORD

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

● ORGANIC CHEMISTRY

I. L. Finar, Senior Lecturer in Organic Chemistry, Northern Polytechnic, Holloway, London. Second edition. Longmans, Green and Co., New York, 1954. xv + 731 pp. Figs. 16 × 25.5 cm. $7.50.

THE author's aim, as expressed in the preface to the first edition, is "to describe the fundamental principles of organic chemistry." The accomplishment of this aim is realized in the presentation of a comprehensive treatment of organic chemistry in terms of modern concepts. Another important objective is found in the value of the book to the student in his study for the General Honours degree in chemistry of the London University.

Dr. Finar has succeeded nobly in presenting, in clear, concise style, fundamental organic chemistry in the traditional pattern (atomic structure, aliphatics, alicyclics, aromatics, and heterocyclics) in the light of electronic interpretations and reaction mechanisms. The bridging of the aliphatics and aromatics with a well written chapter on alicyclic compounds merits commendation. The achievement of the general objective of the book is enhanced by the presentation of a series of typical examination questions, and an appendix which offers excellent information on nomenclature, publications of organic chemistry, and information on searching the literature. The description of Beilstein's "Handbuch" is very instructive and useful. The questions at the end of each chapter are very good, and the references to the literature are pertinent and up to date.

One finds so comprehensive a text wanting, at least in the areas of proteins, fats, soaps, rubber, sulfa drugs, and high polymers. The author, in his preface to the second edition, faces this problem with the statement: "Since I do not consider the chemistry of natural products fundamental chemistry but rather the applications of fundamental principles, I have excluded almost completely the study of natural products." The beauty of the understanding of organic chemistry (it appears to this reviewer) to the student of chemistry is found in the marvelous possibilities of the applications of fundamental principles to products which are familiar (*i. e.*, proteins, fats, plastics, rubber, drugs).

This text, as a whole, is well written, and the author is consistent in his usage of good formulas and illustrative examples; furthermore, the author and publisher have succeeded well in presenting a book relatively free from errors. The British usage of nomenclature may be confusing at certain points, to the American student. This fact is particularly true in the positioning of numerals used in the enumeration of substituents (*e. g.*, butan-2-ol, for 2-butanol, or butanol-2, etc.), and the practice of using the prefix iso- in the I. U. C. system (*e. g.*, isopropanol, isobutene, etc.).

This text will be of great value as a reference to the beginning graduate student of chemistry in the American university, especially for review purposes and extension of his knowledge of modern concepts in organic chemistry. Although it will find limited consideration for adoption as an introductory text in the traditional undergraduate course in this country, it should serve as an excellent reference for every library of chemistry.

ROY G. BOSSERT

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● PAPER CHROMATOGRAPHY

Friedrich Cramer, University of Heidelberg. Second edition. Translated by *Leighton Richards.* St. Martin's Press, Inc., New York, 1954. xii + 124 pp. 68 figs. 4 tables. 16 × 23 cm. $5.

IT SEEMS to be characteristic of paper chromatography that each worker develops his own laboratory methods, and that his modifications which yield excellent results in his hands may prove to be unsatisfactory in the hands of another. This has led to so many modifications of modifications that it would be inadvisable, if not impossible to describe them all in a practical laboratory manual. Considerable judgment must have been necessary to achieve the balanced selection of typical techniques found in this book.

The author commendably states: "Attention is here expressly drawn to the tendency shown by beginners in this field to apply amounts of substance which are nearly always too large.... Paper chromatography is a thorough-going micro-method, and those unaccustomed to working on this scale are very prone to the errors of the novice." The author then proceeds to recommend the application of amounts of substance which, in the reviewer's opinion, are too large. The bibliography seems particularly lacking in references from the United States, but perhaps this makes it all the more valuable to the American student, since most of its 362 references are derived from European sources and hence are less familiar.

Among substances considered are amino acids, proteins, sugars, alcohols, phosphate esters, nucleosides, nucleotides, nucleic acids, flavins, phenols, organic acids and bases, vitamins, antibiotics, porphyrins, sterols, steroids, and dyestuffs. Paper electrophoresis is also briefly touched upon. Most valuable is the detailed description of general and special techniques, with many diagrams and illustrations of the clever little gadgets with which paper chromatography is so replete. This is a good book which every paper chromatographer should have. It has also been translated into Italian.

A. R. PATTON

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● PRACTICAL PHYSICAL CHEMISTRY

Alexander Findlay, Professor of Chemistry, University of Aberdeen. Revised and edited by *J. A. Kitchner,* Imperial College of Science and Technology, London. Eighth edition. Longmans, Green and Co., New York, 1954. xiii + 364 pp. Illustrated. 14.5 × 22 cm. $3.50.

THIS is the most recent edition of a laboratory manual of physical chemistry that was first published in England nearly half a century ago. The revision is conservative and well written.

The emphasis is on relatively simple laboratory demonstrations of physical-chemical laws and concepts. Most of the experiments seem easy to perform, although American undergraduates would probably find the explanations difficult. There is little effort to introduce methods that would be used in practice today or to train the student in experimental or research techniques. There is no discussion of the design of experiments and little on treating data.

It seems improbable that this book will be widely used in this country. Many of the teachers and a few of the students in laboratories of physical chemistry may, however, be interested in reading it. It should be of especial interest to anyone seeking experiments for demonstration lectures in this subject.

CARSTEN STEFFENS

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● COLLEGE CHEMISTRY IN THE LABORATORY. NO. 2

Lloyd E. Malm, Professor of Chemistry, University of Utah, and *Harper W. Frantz,* Professor of Chemistry, Pasadena City College. W. H. Freeman and Co., San Francisco, 1954. xxvi + 342 pp. 102 figs. 21.5 × 27 cm. $3.30.

INTENDED as an alternate edition of this well known laboratory manual, all the experiments of the original manual are retained, several new experiments have been added, and many questions, problems, and other material have been added or changed. Thus, instructors may alternate between the old manual and this new one. Experiments (34–38) emphasizing the principles of ionic equilibria precede those on qualitative analysis (39–44). Experiments are excellent, illustrating chemical principles, and a challenge to students. Although intended to be used with the textbooks of Linus Pauling, it can be successfully used with most other texts. For each experiment there are included perforated sheets for reports of experimental data, calculations, exercises, and problems.

For the benefit of teachers the manual is available in combination with a "Teachers Manual" of 44 pages, which contains suggestions for conducting experiments, lists of supplies, suggestions for quizzes and examinations, and answers to problems and other assignments.

● EXPERIMENTS, THEORY AND PROBLEMS IN GENERAL CHEMISTRY

Hosmer W. Stone and *James D. McCullough,* Professors of Chemistry, University of California, Los Angeles. McGraw-Hill Book Company, Inc., New York, 1953. viii + 352 pp. 43 figs 26 tables. 22.5 × 28 cm. $6.

THIS manual is intended for use by chemistry majors, premedical, and engineering students, and for that reason is rather rigorous and challenging. The authors use it as a text by supplementing it with other reference books, although the extent of the theoretical material appears to be rather limited for this purpose.

The material is divided into eight sections, each consisting of several closely related experiments, totaling 31 experiments in all. The work is broken down in all cases into experimental work with accompanying report which usually is of quantitative nature, theoretical discussion, and problem applications. Perforated pages facilitate handling in the well arranged reports.

An unusual feature is the inclusion in the appendix of sample sets of examinations and a list of answers to problems in addition to the usual tables of information.

● LABORATORY PROBLEMS IN GENERAL CHEMISTRY

Howard Nechamkin, Associate Professor of Chemistry, Pratt Institute. Thomas Y. Crowell Co., New York, 1953. xiv + 274 pp. 16 figs. 14.5 × 22 cm. $2.50.

THIS is a collection of 46 experiments to be used with any standard, college general chemistry text. Practically every experiment is designed to be a challenge to the student by approaching the problem in a manner which is new to him, not a repetition of high-school test-tube methods. Most experiments "involve the solution of a definite laboratory problem based upon the verification of a principle, the clarification of a concept, the determination of a universal constant, the illustration of a commercial process, or the analysis of an unknown mixture." Most experiments depend upon gravimetric, volumetric, or colorimetric procedures. Reports, which are very brief and time-saving for instructors, are made on perforated data sheets. No qualitative analysis is included.

In the appendix are 200 questions and problems and a list of materials needed for 40 students in addition to the usual tables of information.

● LABORATORY MANUAL TO ACCOMPANY "INTRODUCTION TO THE SCIENCE OF CHEMISTRY"

Karol J. Mysels and *Charles S. Copeland,* Associate Professors of Chemistry, University of Southern California. Ginn and Co., Boston, 1952. x + 126 pp. 15 figs. Tables. 19.5 × 26 cm. $1.75.

ARRANGED in the sequence suitable to accompanying the authors' text, this manual consists of 31 experiments of medium difficulty, designed for three hours of laboratory a week for one year. Although most experiments are more or less traditional in type, many of them are conducted with a quantitative emphasis. No systematic qualitative analysis is included although there are a few experiments illustrating analytical principles and interpretations.

All experiments are perforated and punched in order to facilitate handing them in for correction of experimental results and answers to questions and subsequent filing in standard notebooks for later reference. In the appendix are lists of equipment needed per locker and supplies needed per experiment.

● LABORATORY EXPERIMENTS IN COLLEGE CHEMISTRY

V. R. Damerell, Western Reserve University. The Macmillan Co., New York, 1952. iv + 124 pp. 18 figs. 21.5 × 28 cm. $1.75.

CONSISTS of 25 chapters, subdivided into 130 comparatively short experiments, each chapter being about the equivalent of one experiment in other manuals. The material is arranged to accompany the author's textbook but could easily be adapted to other similar situations of terminal courses for average students requiring no qualitative analysis.

Papers are perforated so that questions can be answered and handed in. A list of reagents but not of quantities needed is appended.

● LABORATORY MANUAL FOR INTRODUCTORY CHEMISTRY

Lillian Hoagland Meyer, Western Michigan College of Education. Second edition. The Macmillan Co., New York, 1952. ii + 144 pp. 21.5 × 28 cm. $1.75.

THIS manual is a collection of 42 experiments for terminal students of home economics and similar interests who need a general course which includes organic and biochemistry, but not qualitative. A minimum of quantitative experiments is included, most of them being of the simple test-tube type. Numerous questions are interspersed all through the directions. The pages are perforated for convenience in handing in reports for correction.

● LABORATORY EXPERIMENTS IN GENERAL CHEMISTRY AND SEMI-MICRO QUALITATIVE ANALYSIS

George W. Watt, Professor of Chemistry, The University of Texas, and *L. O. Morgan,* Associate Professor of Chemistry, The University of Texas. McGraw-Hill Book Co., Inc., New York, 1953. viii + 232 pp. 46 figs. 22.5 × 28.5 cm. $3.50.

ALTHOUGH intended to accompany the text "General Chemistry" by Felsing and Watt, this manual is readily adapted to use with other texts. An earlier manual written by Professor Watt was very similar to this except that it made use of a macro method of qualitative analysis.

This manual is divided into two parts, each intended for one semester of work. Part 1 consists of 49 experiments of fairly short duration, a large proportion of them being of quantitative nature with emphasis on principles. The authors have provided for ample attention to safety precautions. Part 2 is a complete

system of qualitative analysis based on the traditional sulfide method using semimicro quantities. Brief reports of data and answers to pertinent questions are facilitated by perforation of the pages.

Included in the appendix are lists of apparatus and supplies needed.

• EXPERIMENTS AND PROBLEMS FOR COLLEGE CHEMISTRY

J. E. Belcher and *J. C. Colbert*, University of Oklahoma. Fifth edition. Appleton-Century-Crofts, Inc., New York, 1953. x + 214 pp. 25 figs. 21.5 × 28 cm. $2.50.

• PROPERTIES AND NUMERICAL RELATIONSHIPS OF THE COMMON ELEMENTS AND COMPOUNDS

J. E. Belcher and *J. C. Colbert*, University of Oklahoma. Fifth edition. Appleton-Century-Crofts, Inc., New York, 1953. x + 374 pp. 42 figs. 21.5 × 28 cm. $3.

Both manuals are especially adapted to use with the Smith-Ehret texts and have page references to them, but are easily adapted for use with other texts. Parts I, II, and III of both manuals are identical. Part I consists of 39 experiments, Part II is an outline of work in first-year chemistry with references to the Smith texts, and Part III is a textbook of chemical arithmetic with lists of problems. Experiments are fairly simple, of traditional type, with complete discussion and directions, and with very detailed and complete reports. Report sheets are perforated to hand in and two blanks for each report are provided so that a carbon copy can be kept by the student. However, the authors themselves point out that this method focuses attention on report writing and encourages copying so do not recommend it. No qualitative analysis is included in this manual.

The appendixes include tables of vapor pressures, atomic weights, logarithms, lists of materials and apparatus required, and indicators.

In addition to the above common material, the "Properties and Numerical Relationships" manual has Part IV, Properties of the Common Elements and Related Compounds, a series of 28 additional experiments similar in nature to those described under Part I, and Part V, Elementary Qualitative Analysis, which is a misleading title in that no systematic qualitative analysis is included. Instead, this is a group of five experiments on amphoteric substances, colloids, solubility product, complex ions, and electromotive-force series.

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• NATURE AND STRUCTURE OF COLLAGEN

Edited by *J. T. Randall*, Honorary Director, Medical Research Council Biophysics Research Unit, and Wheatstone Professor of Physics, University of London, and *Sylvia Fitton Jackson*. Academic Press Inc., New York, 1953. ix + 269 pp. Many figs. Tables. 14.5 × 22 cm. $6.50.

This is a group of papers presented for a discussion convened by the Colloid and Biophysics Committee of the Faraday Society, in 1953.

Chief object of the meetings was to bring together as many of the interested research workers as possible for discussion of the varied biological, physical, and biochemical problems. Approximately 100 people attended the sessions. The 23 papers included form a mosaic of relatively disconnected subjects, though contributing materially to the literature on connective tissues. The papers were interspersed with nine discussion periods bringing out much pertinent information and clarification. The subjects covered in this symposium can be divided into eight natural groups and will be dealt with in what seems like a logical sequence without regard to the order of appearance of the papers in the book.

Three papers are devoted to the origin of collagen under the titles "Metabolism of collagen in the rat," "Fibrogenesis in vivo and in vitro," and "The physical and chemical properties of fibre formation and structure." Three other papers cover the properties of specific materials, reticulin, byssus threads, and dentine collagen.

Physical properties such as X-ray crystallographic studies, high-angle X-ray diffraction, infrared absorption, scattering of light by collagen solutions, quantitative paper chromatography, the electrophoresis of collagen solutions, and Donnan membrane equilibrium are discussed in seven papers.

Two papers are devoted to chemical observations on composition of human subcutaneous tissue and on extracted collagens.

The remaining three groups of papers deal with enzyme studies, three papers; the reconstruction of collagen fibrils, one paper; and there is one paper devoted to the physical and chemical properties of extracted skin collagen.

This book is certainly not designed for the casual reader but has value only for the specialist in the field. From his point of view, it represents a valuable addition to the literature on connective tissue. On reading the book, one is impressed by the number of uncertainties and unsolved problems concerning a substance that certainly must be regarded as one of the simpler tissues in living organisms. He is also impressed by the stupendous amount of work that is represented by a modest advance in knowledge in such a field.

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• THE CHEMICAL STRUCTURE OF PROTEINS

Edited by *G. E. W. Wolstenholme* and *Margaret P. Cameron*. Little, Brown and Co., Boston, 1954. xii + 222 pp. 49 figs. Tables. 14 × 21 cm. $6.

Since 1949 the Ciba Foundation in London has held over two dozen international symposia dealing with selected fields of medical and chemical research. The invited papers, together with informal discussions which follow them, are published in book form. "The Chemical Structure of Proteins" is a report on the meetings held in December, 1952.

The papers deal with three main topics: the isolation of pure proteins and peptides, the characterization of end groups, and the splitting of specific peptide bonds.

Countercurrent distribution methods as applied to the elucidation of the structure of tyrocidine *A* are discussed by L. C. Craig; the purification of ribonuclease and lysozyme with ion-exchange chromatography by W. L. Stein; and the partition chromatography of insulin and glucagon by R. R. Porter. These are three excellent examples of the diversification of techniques used for isolating pure molecular species.

R. L. M. Synge considers the peptides of ordinary tissue and discusses their role in protein synthesis and the effect of their adsorption on the apparent composition of proteins.

Various techniques of end-group analysis are considered. P. Desneuelle and M. Rovery use the Sanger DFP method to study the *N*-terminal groups of trypsinogen, trypsin, chymotrypsinogen, and chymotrypsin. P. Edman discusses his newer phenylisothiocyanate method for *N*-terminal residue analysis, and H. Fraenkel-Conrat describes its use on a variety of proteins. The identification of carboxyl terminal residues by reduction to amino alcohols is considered in two papers by A. C. Chibnall and M. W. Rees, and C. Fromageot and M. Justiez. Recently developed techniques for degrading peptides from the amino and carboxyl ends are described by F. Turba and T. Wieland. These papers well illustrate the variety of chemical methods which are being explored by many different groups.

The important problem of selective cleavage of amino-acid chains by bringing about acyl migrations from amino to neighbor-

ing hydroxyl groups in serine and threonine is considered in a paper by D. F. Elliott. This approach is most valuable in that it offers a potentially reliable method for controlling the breakdown of longer peptide chains, thereby reducing the sequential analysis of larger proteins to problems of the magnitude of insulin.

Initial experiments in the formidable task of fractionating the pepsin hydrolyzate of crystalline albumin are outlined by P. Boulanger and G. Biserte. The composition and analysis of the highly basic proteins located in cell nuclei, the protamines, and nucleoprotamines are described by K. Felix. E. L. Smith discusses the use of specific peptidases in analyzing peptide structure.

Two papers discuss the difficult and controversial problem of collagen structure. W. A. Schroeder describes his chromatographic experiments on different hydrolyzates and considers the various theories of collagen structure in the light of his results. Electron microscopy and chemical analysis of various collagen peptides are discussed by W. Grassmann.

This is a very useful book which summarizes some of the progress in a field of chemistry that is growing very rapidly. It is unfortunate, however, that there was a 16-month delay between the symposium and the publication date. Nonetheless, the book can be recommended for the advanced student and the research worker. The informal discussions following the papers provoke in the reader a sense of participation, answering as they do many of the questions he may raise himself.

ALEXANDER RICH

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● CHEMICAL BUSINESS HANDBOOK

Edited by *John H. Perry*, E. I. du Pont de Nemours & Company. McGraw-Hill Book Company, Inc., New York, 1954. xiii + 1354 pp. Many figs. and tables. 19 × 26 cm. $17.

Since 1934 the name of John H. Perry has been synonymous with data for the chemical engineering profession. The popularity and utility of the "Chemical Engineers' Handbook" are shown by the fact that the book now is in its third edition, with major changes and expansion in each edition.

Now another phase of the chemical industry has been brought together in one volume which will serve as ready reference to both the young engineer who wants to learn and the older business man who wants to refer to current practice in business phases of the chemical industry.

The young engineer in industry finds that he must expand beyond his sphere of technical knowledge. Possibly he first finds that he is in contact with the patent department and his patent application; possibly it is the accounting department and inventories; certainly he must prepare reports. As he continues in the company other phases of business operations are superimposed on the technical background: personnel management, production, public relations, commerical chemical development, and the like. All of these are discussed in the twenty sections of the book.

Each section is preceded by a detailed outline of the contents. This is in addition to a complete final index of the handbook. The sections and pages devoted to each are: Business Finance (51 pages), Management and Control by Cost Accounting and Planning (90), Commerical Chemical Development (48), Research (43), Market Research (59), Market-research Data and Sources of Information (282), Industrial Purchasing (36), Production (82), Traffic and Transportation (72), Sales (71), Industrial Advertising (21), Credits and Collections (33), Personnel Management (35), Public Relations (14), Business Law (42), Patents and Patent Law (20), Industrial Toxicology (16), Insurance and Loss Prevention (46), Reports and Report Writing (62), Business Mathematics (200), and Index (31).

The list of 124 contributors to this handbook shows men who are widely known as experts in the chemical business field. So many "voices of experience" must have much to relate that will be of use to the one seeking information outside of his own field.

In college, the emphasis must be on the technical aspects of the chemical engineering profession. Because so many of the graduates become more and more engaged in the business aspects of the chemical industry, we must make available to our students and introduce to them this "Chemical Business Handbook" so they will know where to turn for information as they encounter business rather than technical problems.

KENNETH A. KOBE

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● SYNTHETIC METHODS OF ORGANIC CHEMISTRY. VOLUME 7

W. Theilheimer. **Interscience Publishers, Inc., New York, 1953. xi + 450 pp. 16 × 23.5 cm. $15.**

This is the seventh volume of this series, which now has become an annual publication. Reviews of the other volumes have appeared in the following numbers of this Journal: **23,** 310 (1946); **26,** 53 (1949); **27,** 234 (1950); **30,** 214 (1953); to which the reader is referred for a more extensive description of the symbolism employed to arrange the syntheses according to the types of bonds made and broken.

The present volume lists 919 abstracts of organic syntheses that appeared for the most part between 1950 and 1952. The abstracts consist of an average of about five lines. Of 250 abstracts examined, only two exceeded ten lines. The origins of the abstracts are 60 per cent American (*J. Am. Chem. Soc., Org. Syntheses,* and *J. Org. Chem.*); 17 per cent British; 9 per cent German; 5 per cent Swiss; 4 per cent French; 2 per cent Scandinavian; 2 per cent Russian; and 1 per cent others (Italian, Indian, etc.).

Previous reviews in this Journal and other American scientific journals as to the value of Theilheimer's work vary from enthusiasm for "the wealth of practical information placed at the disposal of the laboratory worker" to skepticism since "such an ambitious enterprise falls short of satisfactory accomplishment." The symbolism used to arrange the syntheses has been described as all the way from "simple" and "easy" to "mystic," "difficult," and of "doubtful value."

Without aligning himself with either favorable or unfavorable critics the present reviewer merely registers his own experience with this and previous volumes of the series. It is difficult to become accustomed to thinking in the symbolism employed to arrange chemical reactions. This is true not only of older persons who have been conditioned but of younger students as well. For the practicing organic chemist this work has a definite value, whether or not he learns the symbolism, because there is an adequate index. For the student in preparative organic chemistry, whether undergraduate or graduate, abstracts of syntheses consisting of about 50 words have been found insufficient except as a reference to the original publication.

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● ELEMENTARY INTRODUCTION TO MOLECULAR SPECTRA

Børge Bak. **Interscience Publishers, Inc., New York, 1954. x + 125 pp. 35 figs. 17 tables. 14 × 21.5 cm. $2.90.**

According to the author's preface, this book was written to supply a background of fundamental principles of spectroscopy for those biologists, chemists, and chemical engineers (and po-

sibly for prospective spectroscopists) who use spectroscopic instruments and techniques. It must be admitted that most of these principles are here, but there is considerable doubt that they can be understood properly by these readers, unless additional texts are consulted.

About a quarter of the book (Chapter III, 34 pages) is given over to highly condensed mathematical derivations of some quantum mechanical results. But little is done toward application of these results in the descriptive parts which follow. Indeed, the author states that he has attempted to make these parts independent of the mathematical derivations. It may be asked, then, why this material is included. There are many texts on quantum mechanics which correlate experimental results with theory very successfully, and these should not be too difficult for the nonspecialist. It is true that such books are longer, and brevity has been evidently one of the principal aims of the author. In my opinion this is the principal fault of the book; it is too brief to be of any value.

The importance of molecular symmetry in the understanding of spectra is only briefly indicated. It might have been better to have enlarged the discussion of this topic, and omitted some of the details of the quantum mechanics of the particle in the box. The book is best in its brief discussion of microwave and of infrared spectra, and it is weakest in the treatment of Raman and electronic spectra. I do not believe that a reader can obtain a correct idea of the Raman effect and of the mechanism of fluorescence from this book. Instead he may easily obtain a confused or an incorrect impression of these phenomena.

A. B. F. DUNCAN

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● INDUSTRIAL FERMENTATIONS. VOLUME I

Edited by *Leland A. Underkofler*, Professor of Chemistry, Iowa State College, and *Richard J. Hickey*, Research Microbiological Chemist, Commercial Solvents Corporation. Chemical Publishing Co., Inc., New York, 1954. ix + 565 pp. 72 figs. 55 tables. 14.5 × 22 cm. $12.

This symposium represents the efforts of 19 qualified contributors. The resulting volume is authoritative, concise, and largely up to date. As is to be expected, a work of this type is marked by variations in style and treatment that do not make for maximum convenience to the reader, although this is a minor defect that is overshadowed by the excellent coverage given to present-day fermentation technology.

The book should enjoy maximum utility as a reference work. In this category and as a text it will serve admirably to complement the well known "Industrial Microbiology" of Prescott and Dunn. Subject matter is divided into four sections that stress commercial processes of actual or potential importance. Part one is devoted to alcoholic fermentations and includes chapters on the fermentations of grain, molasses, sulfite waste liquor, and wood waste; a chapter on the brewing industry; one on wine production; and another on glycerol production. Part two is restricted to yeast production, including commercial yeast and food and feed yeast. A single chapter on the butanol-acetone fermentations constitutes the third section of the book. The six chapters of part four are given to the fermentative production of the following acids: lactic, citric, gluconic, fumaric, itaconic, and acetic.

Great detail is effectively condensed and presented. A comprehensive subject index is included, and the trend toward literature condensations is emphasized by a bibliography of nearly 1200 entries. Unfortunately, these are advantages for which the reader must pay dearly. In the reviewer's opinion, it is somewhat difficult to reconcile the price of the book with the quality of the format.

WILLIAM D. ROSENFELD

California Research Corporation
La Habra, California

● THE DETERMINATION OF CRYSTAL STRUCTURES

H. Lipson, Manchester College of Technology, and W. Cochran, University of Cambridge. Edited by *Sir Lawrence Bragg*. The Macmillan Company, New York, 1953. ix + 345 pp. 325 figs. 328 tables. 15 × 22.5 cm. $8.

The field of X-ray crystallography has developed so extensively during recent years that it is now a most powerful method for determining molecular configurations and dimensions. Substances as complex as penicillin and strychnine have yielded to this form of analysis, often without prior knowledge of their chemical structures. Improved techniques and methods of refinement now make it possible to determine bond lengths in the simpler molecules to within a limit of error of 0.01 Å.

However, until now there has been available no textbook which could serve as a comprehensive introduction to this field. The publication of this volume is therefore most welcome.

The authors, both well known crystallographers, have attempted to cover the methods of crystal-structure determination from the stage at which a set of structure amplitudes has been obtained to the final accurate positioning of the atoms. The opening chapter contains a concise introduction to X-ray optics, and the following three chapters deal with the routine matters of space-group determination, calculation of structure factors, and summation of Fourier series.

The remaining two-thirds of the volume deals with the more difficult problems of the derivation of atomic coordinates, their refinement, and with methods of assessing the accuracy of the completed structure determination. "Trial and error" methods, the Patterson function, Fourier methods, and the so-called direct methods are each dealt with in separate chapters, accompanied by extensive references to publications. Each chapter contains a number of examples taken from the literature to illustrate the methods described.

The format is excellent, and there appear to be few printing errors. It will appeal both to the beginner as a lucid introduction, and to the experienced crystallographer as a comprehensive review of crystal-structure determination.

DAVID R. DAVIES

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● COLORIMETRIC METHODS OF ANALYSIS. VOLUME 4

Foster Dee Snell and Cornelia T. Snell. Third edition. D. Van Nostrand Co., Inc., New York, 1954. vii + 676 pp. 22 figs. 18 tables. 16 × 23.5 cm. $12.50.

This book completes the third edition of the well known work of the authors. It includes some turbidimetric and nephelometric methods and contains all remaining organic and biological material that could not be incorporated in the third volume because of space limitations. The sixteen chapters cover nitrites and nitro compounds; aliphatic amines and amides; amino acids; proteins; aromatic primary, secondary, and tertiary amines; azo compounds, nitrogen-containing cycles, etc.; urea and related compounds; compounds with inorganic radicals; sterols; hormones; alkaloids; enzymes; antibiotics; hemoglobin and related compounds; natural pigments; and color of liquids.

"As in the second edition the aim of this edition has been completeness but so many new methods appear in this field that much condensation is necessary." The authors have, however, "attempted to include, or refer to, the methods that have been published since the second edition, up to the time of publication. This has meant deleting many of the older references. Alternative methods for a particular substance are still given, because a method suitable for one purpose may not be suitable for another." Explanatory matter has of necessity been held to a minimum, but since the introductory paragraph explains the

principle and limitations of each method, the reader should be able to decide which one of the alternative methods will be best applicable to his needs. Usually substances that interfere are mentioned in the introductory paragraph and then methods for their removal are described under "sample." The success of a method often depends not only on the proper treatment of the sample to remove substances that would interfere with the color development, but also on the preparation of a solution with a suitable concentration of the constituent to be determined; hence the preparation of sample is given in considerable detail. The precision, accuracy, time required for color development, and wave length are usually stated. The text includes 18 tables of useful data and numerous references to the original literature, the latter being conveniently listed at the bottom of the pages. Author and subject indexes conclude the book. Paper, printing, and binding are good and no serious typographical errors were noted.

Volume 4, together with Volumes 1, 2, and 3, presents an extensive and up-to-date treatment of colorimetric methods of analysis. This set will be useful to anyone who needs to make chemical analyses, especially when small quantities, even trace amounts, are to be determined.

JOHN H. YOE

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Charlottesville, Virginia

● CHEMOTHERAPY OF INFECTIONS

H. O. J. Collier, **Chief Pharmacologist, Allen and Hansburys Ltd. John Wiley & Sons, Inc., New York, 1954. xvi + 248 pp. 58 figs. 21 tables. 14.5 × 19 cm. $4.**

In this compact little volume Dr. Collier has given us an almost full picture of many aspects of chemotherapy. After setting forth in clear and simple language the fundamental principles of the field, he discusses the importance of selective toxicity of chemotherapeutic agents for the pathogenic microbes and the absorption, distribution, and excretion of the drugs. Then follows a chapter on the mechanism of action of the drugs, and one on microbial resistance. This chapter is among the best descriptions of this complex subject which the reviewer has seen. The concept of antibiotics, their history, and methods of discovery are discussed next. Special chapters are devoted to penicillin and streptomycin, and the preparation, unit measurements, mode of action, and uses of these compounds are described well. The other antibiotics are relegated to subordinate places, and more recent ones such as erythromycin are not mentioned. The last six chapters deal with synthetic drugs, from Ehrlich's arsenicals to the latest useful antimalarials, antituberculous agents, and drugs for various tropical infections. These chapters are arranged according to the diseases in question and present drugs of all pertinent structures under these headings. The descriptions of the biology of the pathogens are especially good, while underlying chemical relations are at least pointed out. There is a subject and author index, and 278 references guide the reader to the most important articles on chemotherapy.

Few authors have the ability to write for the various levels of education and specialization of the readers to whom this book can be recommended. Dr. Collier starts so simply to break the reader into his subject matter, and raises the niveau of the material so slowly, that college students, graduate, or medical students, as well as their teachers will find it enjoyable. Physicians and pharmacists will find a wealth of background material for the drugs they use in their practice, and the educated layman will readily understand the development and theories of a subject which has freed this and coming generations from some of the most dreaded scourges of mankind.

ALFRED BURGER

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● BILDER ZUR QUALITATIVEN MIKROANALYSE ANORGANISCHER STOFFE

Wilhelm Geilmann, **Professor, Johannes-Gutenberg Universität Mainz, Germany. Verlag Chemie, GMBH, Weinheim, Germany, 1954. 120 pp. Many illustrations. 16.5 × 23.5 cm. DM 20.80.**

Bilder means pictures; "guessing German" plus occasional use of a dictionary is enough for effective use of this book, in which half the space is given to 393 uniformly excellent photomicrographs. There is no text other than a few lines for each illustration, stating the method of carrying out the reaction, sensitivity, and interferences. The arrangement is by analytical groups rather than by the periodic table, with indexing by ions and by reagents that indicates the preferred tests of the several ones given.

No general analytical scheme is included; the work is not presented as a manual of microscopical analysis, but as a supplement to other analytical methods. It covers a wide variety of specific crystal-precipitation reactions, such as might be used for "yes or no" or confirmatory tests for inorganic anions and cations.

This book is strongly recommended to analysts who are already familiar with microscopical qualitative reactions, and to others who might want to employ them occasionally. For the latter, the reviewer would urge what all chemical microscopists know—the value of trying out a test on knowns, with some variations of concentrations and admixture of possible associated ions, rather than leaning on pictures alone when tackling unknowns. As the author emphasizes, a photograph represents an arbitrary selection of what may be typical but cannot be all inclusive. It should serve as a refresher of the visual memory of one's direct observations, in the making of which valuable experience was gained, rather than for the recognition of "total strangers."

C. W. MASON

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● FLUORESCENCE OF SOLUTIONS

E. J. Bowen, **Fellow of University College, University of Oxford, and** ***Frank Wokes,*** **Director of Ovaltine Research Laboratories, England. Longmans, Green & Co., Inc., New York, 1953. vii + 91 pp. 34 figs. 11 tables. 14.5 × 22 cm. $4.75.**

The combining of the theoretical background of Bowen with the practical experience in fluorescence analysis of the coauthor has produced an excellent book. The authors state that they have written to provide an introduction to fluorescence for the practical worker and the student. This has resulted in a text that is easy to read and is at the same time thoroughly instructive. A critical condensation of theoretical material has been presented in such a manner as to stimulate interest in theory as well as to allow an understanding of the more practical aspects of fluorescence. The book is well referenced, but it is not the review type that requires too much discrimination for the beginner in the field.

The subject matter progresses from a consideration of theoretical fundamentals, touching on wave mechanics, to instrumental factors affecting fluorescence and the theory and kinetics of quenching. Chapters on detecting devices, fluorimeters, the measurement of fluorescence, and fluorimetric assays make up the second half of the book. The treatment of these technological aspects of fluorescence is quite thorough and includes a discussion of the instruments and methods currently in use. The reader is made aware of the many pitfalls awaiting the inexperienced worker and is shown how to avoid them. With the aid of this book, one totally new to the field should be able to approach fluorimetric analytical procedures with a degree of confidence.

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• SCHOOL FACILITIES FOR SCIENCE INSTRUCTION

Edited by *John S. Richardson.* Compiled by a committee of the National Science Teachers Association, Washington, D. C., 1954. viii + 266 pp. Illustrated. 22 × 28.5 cm. $5.50.

BECAUSE there was no comprehensive and authoritative publication on science teaching facilities available to science teachers and school administrators, the National Science Teachers Association approved a project in 1948 for the preparation of such a publication. "School Facilities for Science Instruction" is the full report of the project. Concerned as it is with many aspects of science teaching—laboratories, multipurpose science rooms, rooms for developmental science courses and specialized courses; audio-visual facilities; facilities for elementary schools; equipment and supplies, storage and preparation; checklists of equipment and supplies; sources of furniture, equipment, and supplies; and college facilities for the education of science teachers—the book will be useful to a wide range of persons responsible for planning and teaching science.

School administrators will welcome such an authoritative report; and architects, science supervisors, school boards, and state departments of education, as well as those who sell to our schools and colleges, can profitably utilize the information found in this report, brought together by the committee and a large number of contributors from all parts of our country in the public schools and colleges and universities—school plant specialists, members of school boards and state departments of education, whose names are all listed in Appendix I. A special reviewing committee studied the manuscript with representatives from the National Council of Chief State School Officers, Association of Secondary School Principals, Department of Elementary School Principals, American Institute of Architects, National School Boards Association, National Council of Schoolhouse Construction, and the U. S. Department of Education.

It is profusely illustrated with diagrams and pictures, showing not only the laboratories and classrooms, but a wide variety of facilities for learning activities. The amount of material assembled here to show the basic principles concerning facilities for science instruction is amazing. This project of the National Science Teachers represents a tremendous effort to give to those who build the schoolhouses of the nation the facilities for science teaching that can make the lives of our youth more effective through the contributions of effective science teaching.

GRETA OPPE

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• MINERALS FOR THE CHEMICAL AND ALLIED INDUSTRIES

Sydney J. Johnstone, Ministry of Economic Warfare, London. John Wiley & Sons, Inc., New York, 1954. 692 pp. 174 tables. 14.5 × 22 cm. $11.50.

IN RECENT years, the quantities and varieties of mineral materials required by industry have increased greatly. The depletion of the richest sources of some minerals, coupled with international tensions which hamper trade, have created severe problems of supply. As a consequence, there is mounting interest in industrial minerals. Numerous articles, reports, and books have appeared within the last few years dealing with one or another aspect of mineral materials of commercial importance. Mr. Johnstone's "Minerals for the Chemical and Allied Industries" is a noteworthy addition to the growing literature on the subject.

This book brings together in a single volume data concerning the sources, world production, methods of processing, and uses of all the major industrial minerals, exclusive of fuels and certain construction materials. There are 71 chapters, each dealing with a single mineral, or a small group of minerals of similar uses. The concise style of writing has made it possible to include a large amount of material in each relatively short chapter.

Since the book was written by a British subject, the terminology reflects English usage. Statistics concerning production and consumption of minerals in Great Britain are given prominence but no more so than those for the United States. In fact, very liberal use has been made of publications originating in the United States in compiling the factual data. The book was written primarily for producers and consumers of mineral materials. For this reason, much attention is given to the specifications which mineral materials must meet in order to be marketable. The book is as up to date as is possible in a work of this kind since official statistics are usually at least a year late in appearing.

Although the book will be of greatest value to those directly concerned with the mineral industries, it should be a valuable reference for teachers of chemistry, particularly those dealing with beginning courses in secondary schools, colleges, and universities. In the opinion of this reviewer, it is as much the function of these courses to show the importance of chemistry as a tool of industry as it is to lay a foundation for later courses in chemistry. While the chemistry of processing minerals and converting them into finished products may lack the glamor of organic syntheses, it is nonetheless of tremendous importance industrially and deserves more consideration in the general chemistry course. The teacher who holds this point of view could do no better than to use "Minerals for the Chemical and Allied Industries" as a basic reference. The chemical processes used in preparing minerals for use in industry and in converting them into useful products are very well discussed. They provide excellent examples of the practical importance of chemistry in modern industry.

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• NOTIONS ÉLÉMENTAIRES DE CHIMIE GÉNÉRALE À LA LUMIÈRE DES THÉORIES MODERNES

***Paul Pascal,* Professor, l'École Normale, Paris. Masson et Cie, Paris, 1953. xxxi + 550 pp. 243 figs. Tables. 16.5 × 24 cm. 3600 fr. ($10.30). Paper bound.**

THE "Advertissement" states that in a previous 1800-page treatise the author has written a theoretical and critical exposition of the principal problems of physical chemistry for professional chemists. The present work contains a choice of themes from the preceding tome, limited to those topics for which the exposition is compatible with mathematical apparatus consisting only of elementary algebra. The text presumes a considerable knowledge of analytical, inorganic, and organic chemistry. According to the reviewer's informant, it is used by French students who have had an introductory course in these subjects. In subject matter and scope, the book is somewhat more advanced than an American text for the undergraduate physical chemistry course, but it demands less mathematical knowledge from the student and, of course, it offers him a less penetrating grasp of the subject.

In addition to containing an interesting anecdote about Napoleon, the preface states the author's belief that French science texts have lagged behind those in Anglo-Saxon countries in presenting a modern treatment of their subjects. The author hopes that his text will help to overcome this deficiency, and that, in particular, it will show the student that the main task of modern chemistry is the explanation of the properties of matter in terms of atomic and molecular structure.

The general fields of nuclear physics and chemistry, atomic and molecular structure, chemical kinetics, equilibrium, liquids, and colloids all receive major treatments. The number and variety of particular topics considered is impressively great. It is pleasing to find a brief mention of shock waves, detonations, and flames

in the section on chemical kinetics. There are many particular criticisms that can be made about the section on molecular structure; for example, the tables of interatomic distances on pages 124–5 are out of date and incorrect in a way that is seriously misleading. Nevertheless, the reviewer believes that the student can get a good general idea of molecular structure and valence from the text. He does not believe that the sections on chemical kinetics and equilibrium give a proper insight into the really important features of these subjects. Neither statistical mechanics nor the statistical theory of reaction rates is treated.

Presumably, the principal purpose of a review of a French text in THIS JOURNAL is to provide the readers with some information about chemical education in France rather than to help them decide whether or not to purchase the book. Nevertheless, it may be appropriate for the reviewer to express his opinion that students who wish to practice their French can do just as well by reading the original literature as by reading a book such as this.

The language of number and chemical symbols is universal and even a reviewer born and bred in Chicago can perform, for a French book, the traditional rite of the reviewing craft of pointing out a typographical error when in a one-page section on "Les Bombes Atomiques" it is stated that U^{235} is separated from U^{238} by diffusion of the gas UF_5.

NORMAN DAVIDSON

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● ATOMIC AND FREE RADICAL REACTIONS

E. W. R. Steacie, President, National Research Council of Canada. Second edition. Reinhold Publishing Corp., New York, 1954. American Chemical Society Monograph No. 125. Volume I, x + 485 pp. 64 figs. 128 tables. Volume II, 414 pp. 14 figs. 25 tables. 15 × 23 cm. $28.

IT IS a privilege to review this monumental monograph which comprises the second edition of Dr. Steacie's earlier work, which was A. C. S. Monograph No. 102, of 548 pp. It will be noted from the comparative sizes that the present work constitutes a virtual rewrite of the earlier effort.

The feature of this work which is the most impressive is that it is a critical, not just comprehensive survey of vapor-phase, atomic, and free-radical reactions covering all of the new work to about June of 1953, and all work in this field in the principal journals to September of 1953. As it is limited to vapor-phase reactions, most of the polymer chemists and certain of the other free-radical proponents may not find the treatise of great interest. However, it does fill a very real need and does this very well.

The contents of Volume I are as follows: (I) Introduction, pp. 1–11; (II) Experimental Methods, pp. 13–70; (III) Bond Dissociation Energies, pp. 71–98; (IV) Free Radicals and Thermal Reactions, pp. 99–274; (V) Free Radicals and Photochemical Reactions, pp. 275–485. Volume II contains the following sections: (VI) Types of Elementary Reactions, pp. 487–510; (VII) Systems Containing Carbon and Hydrogen Only, pp. 511–92; (VIII) Systems Containing Oxygen, pp. 593–633; (IX) Systems Containing Nitrogen, pp. 635–55; (X) Systems Containing Chlorine (and Fluorine), pp. 657–99; (XI) Systems Containing Bromine, pp. 701–32; (XII) Systems Containing Iodine, pp. 733–47; (XIII) Systems Containing Sodium, pp. 749–78; (XIV) Systems Containing Other Metals, pp. 779–83; (XV) Systems Containing Sulfur, pp. 785–8; a Bibliography containing 2086 references (!); a Reaction Index in which all the elementary reactions are cross-indexed back to the pages on which they are discussed, pp. 839–64; an Author Index in keeping with the magnitude of the Bibliography; and a comprehensive Subject Index.

The format is particularly impressive, for each of the individual elementary steps is given in bold type, as a heading for the discussion which follows, so that it is quite easy to trace any given step. The binding is excellent. The book is remarkably free from errors; indeed, this reviewer noticed only one trivial point—that in the Table of Contents of Volume II, page 776 should have been listed as 779.

Dr. Steacie is indeed to be complimented on his accomplishment of assembling for the gas-phase kineticists all of these data. He pays noteworthy tribute to his colleagues who have collaborated with him.

The only unfavorable comment which this reviewer can make is one regarding the price, which is such as to keep this monograph off most individual's bookshelves and thus limits it largely to institutional or depository libraries.

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● MONOMOLECULAR LAYERS

Edited by _Harry Sobotka_. American Association for the Advancement of Science, Washington, D. C., 1954. vii + 207 pp. Illustrated. 16 × 23.5 cm. $4.25.

THIS book of two-hundred odd pages is the outgrowth of a symposium at the Philadelphia meeting of the American Association for the Advancement of Science in December, 1951. In order to make this volume a cross section of recent progress in monomolecular layers, a number of workers in the field, not included in the symposium, have been invited to make contributions. With one exception the work is confined to the United States and as a consequence must be regarded as regional.

The opening chapter gives an admirable thumbnail sketch of the history of the science of surface films, followed by descriptions of an automatic dipping machine to make built-up films, a recording ellipsometer for the study of solid-liquid surfaces, and a recording film balance. These automatic machines make more extensive and more detailed observations possible.

As might be expected, improvements in techniques appear frequently throughout the volume. For example, a horizontal film balance capable of reproducible results to 0.01 dyne per centimeter is described, and molecular weight determinations for several proteins are reported by means of it. Radiotracers were made use of by two groups. Both cationic and anionic surface-active ions were tagged, and evidence of multilayer surface adsorption, in some cases up to thirty layers, was presented. This is the first time that direct measurement of previously postulated multilayers has been made. Carbon-14-tagged monolayers of stearic acid were demonstrated to be unique sources of radiation owing to the negligible thickness.

Papers on the mechanical properties of surface films and on chemical reactions taking place in films complete the book. It is a good contribution to the literature in spite of the belated date of publication. Anyone working in this field or wishing to become informed in it will find every paper worth reading.

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● QUALITATIVE ANALYSIS AND CHEMICAL EQUILIBRIUM

T. R. Hogness, Professor of Chemistry, University of Chicago, and _Warren C. Johnson_, Professor of Chemistry and Chairman of the Department of Chemistry, University of Chicago. Fourth edition. Henry Holt and Company, New York, 1954. xiii + 621 pp. 58 figs. 54 tables. 14 × 21.5 cm. $5.

PREVIOUS editions of this very successful text and of two abbreviated presentations of its material have been reviewed in THIS JOURNAL (**14,** 448 (1937); **15,** 448 (1938); **19,** 48 (1942)). The authors consider the present fourth edition as a first step in the

integration of qualitative analysis with general chemistry and announce another text in which the two fields will be "fused." However, they also intend to continue with occasional revisions of the present text.

Chapters 1 (The Atomic and Molecular Concept of Matter), 4 (Quantized Atoms and Molecules), and 14 (Nuclear Chemistry) are new. Although this material has little to do with qualitative analysis, the authors feel that it cannot be neglected in a modern text. Chapter 11 on Complex Ions has been considerably revised through the introduction of considerations on molecular orbitals.

The procedures of Part II have been largely rewritten to introduce centrifugation as an alternative to filtration. The use of thioacetamide is presented as an alternative to that of the ordinary source of hydrogen sulfide. However, the hydrolysis of thioacetamide is rather slow and many instructors will no doubt continue to prefer the old method, particularly since semimicro analysis leads to a marked decrease of contamination of the laboratory atmosphere.

The sections on cation analysis have been expanded, while those on anion analysis have been reduced, the objective in both changes being the greatest possible emphasis on chemical principles rather than on isolated facts.

The tables in the appendix have been thoroughly revised. In particular, the table of solubility products of sulfides has been corrected on the basis of the new values for the dissociation constants of hydrogen sulfide.

With its wealth of clearly presented discussions, of well tested practical details, of well chosen examples, of problems and review questions, of exhaustive tables of data, etc., this book will remain one of the very best pedagogical achievements in chemistry.

PIERRE VAN RYSSELBERGHE

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● BEITRAGE ZUR GESCHICHTE DER NATURWISSEN SCHAFTEN UND DER TECHNIK. VOLUME 2

Edmund O. von Lippmann. **Edited by *Richard von Lippmann.* Verlag Chemie, GMBH, Weinheim, Germany, 1953. xii + 357 pp. 16.5 × 23 cm. DM. 21.80.**

FROM 1878, when von Lippmann began work on the chemistry of sugar, many papers appeared from his pen on sugar chemistry and technology as well as on other technological problems. His papers on the history of science and technology were first gathered into the "Beiträge" in 1923. The present volume under review includes 72 works which appeared in the years 1923 to 1940. Among the articles reprinted are those dealing with the chemistry in the Papyrus Edwin Smith, Herodotus, Lucretius, Alexander von Humboldt, Boerhaave, Alexander Neckham, Jabīr, Newton, Achard, and Kopp. The volume contains excellent indexes of geographic names, proper names, authors' names, and subject matter. An appendix, of interest to historians of chemistry, lists the historical works of each author in their order of publication; a second appendix lists the works according to their historical period of reference. These provide a handy list of those works which have been collected and published in the two volumes of the "Beiträge" and in the two volumes of his "Abhandlungen und Vortragen zur Geschichte der Naturwissenschaften" (1906, 1913). Not only are the von Lippmann volumes indispensable for those doing scholarly work in the history of ancient chemistry; they also provide interesting and readable accounts of chemical techniques and chemists of ancient times and of the more recent past.

MARTIN LEVEY

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● MAN'S FOOD: NUTRITION AND ENVIRONMENT IN FOOD GATHERING TIMES AND FOOD PRODUCING TIMES

Lloyd B. Jensen, **Research Laboratories, Swift & Co. The Gerrard Press, Champaign, Illinois, 1953. x + 278 pp. 16 × 23.5 cm. $4.50.**

THIS book is concerned with the nutritional influences of various foods on the development of man, and with an introductory survey of foods used by man from the paleolithic epochs to the close of classical times. Dr. Jensen shows that civilization was able to develop only after man did not need to spend most of his time gathering his food supply.

The book is divided into three major sections, dealing with (1) food-gathering times, (2) food-producing times, and (3) food, environment, and man's nutrition. The first portion of the book deals with methods used by the food-gatherers, both pre-*Homo sapiens* and early *Homo sapiens*, in getting their food, and with the type of food which these species ate. It is unlikely that we would now consider such foods (earthworms, slugs and grubs, insects, human flesh, etc.) as suitable, although the author does show that such food materials have nutritional value. In connection with this section, it is doubtful that "the layman with an interest in science and history will find this book fascinating reading." The first section of the book (40 pages) could be improved by either incorporating a glossary or by the use of explanatory material about the anthropological nomenclature used.

The second section of the book, dealing with food-producing times, covers the period from the neolithic age to the spread of of food production to Europe. The development of cereals, garden foods, and of protein foods is discussed. In the third section, the social and cultural aspects of nutrition, the effect of nutrition on bodily change, and the effect of nutrition on man's welfare are considered. Some 600 references to the literature are arranged alphabetically at the end of the book.

The book is well printed, neatly bound, and there are remarkably few typographical errors. The author states that it is his opinion this book should prove of value to food technologists, nutritionists, physicians, biochemists, home economists, dieticians veterinarians, microbiologists, and students of agriculture.

MORRIS B. JACOBS

BAYSIDE, NEW YORK

● ENTSTEHUNG UND AUSBREITUNG DER ALCHEMIE. VOLUME 3

Edmund O. von Lippmann. **Edited by *Richard von Lippmann.* Verlag Chemie, GMBH, Weinheim, Germany, 1954. 166 pp. 16.5 × 23 cm. Paper bound. DM 14.**

FROM 1886 until his death, von Lippmann (1857–1940) devoted his leisure hours to the study of the history of chemistry. His works have well earned him a place as the outstanding historian of chemistry of his time. The "Entstehung" stands out as one of his most important works. The first volume appeared in 1919 followed by the second in 1931. The present volume is the last readied for the press before the death of the author. It is arranged in the same alphabetical order of topics as were the earlier two volumes. Many subjects, which were treated in the earlier volumes, however, are brought up to date (1939). Particular emphasis is paid to the history of alchemy with attention devoted to Albertus Magnus, Jabīr, Gerber, Hermes, Trismegistos, Paracelsus, al-Rāzī, the Philosopher's Stone, and the *Turba Philosophorum*. In addition, there are included convenient indexes of authors, geographic and proper names, and subject matter. It is a volume which should be especially useful to workers in ancient and medieval chemistry.

MARTIN LEVEY

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● PLASTICS ENGINEERING HANDBOOK

Society of the Plastics Industry, Inc. **Second edition. Reinhold Publishing Corporation, New York, 1954. xxxv + 813 pp. Many figs. Tables. 16 × 24 cm. $15.**

HERE, certainly, is a cooperative effort in which an entire industry has placed its technical know-how at the disposal of the S. P. I.'s committees charged with the preparation of the various sections and chapters of this handbook.

This second edition is far more comprehensive than the first edition published in 1947, and has about twice as many pages. The present book contains 20 chapters divided into five major sections: I, Materials and Processes (399 pages); II, Design (212 pages); III, Finishing and Assembly (119 pages); IV, Testing (23 pages); and V, S. P. I. Standards (35 pages).

The first section, on materials and processes, classifies rigid molding materials and then describes in a technical manner the various molding and forming processes and equipment. Excellent and ample illustrations and graphs accompany the text material. Included are lengthy chapters on laminated products and vinyl dispersions. The second section, on design, gives the basic principles of mechanical design of molded articles, standards for tolerances, design standards for inserts, and mold design.

The third section is concerned with the methods of machining, finishing, decorating, cementing, welding, and gluing of the product. It must then be tested, and section four gives various test methods. Section five gives the voluntary commercial standards of the trade.

In addition to ample illustrations in the text material, there are a number of large, fold-out illustrations and tables that give much information so that comparisons can be made.

This handbook is essential to anyone working in the plastics industry. To others who desire to know the mechanics of going from the chemical polymer to the finished article, the information is all available here.

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● X-RAY DIFFRACTION PROCEDURES FOR POLYCRYSTALLINE AND AMORPHOUS MATERIALS

Harold P. Klug **and** ***Leroy E. Alexander,*** **Mellon Institute. John Wiley & Sons, Inc., New York, 1954. xiii + 716 pp. Illustrated. 15.5 × 23.5 cm. $15.**

AS FAR as the reviewer knows this is the first attempt at a modern, comprehensive treatise on X-ray diffraction procedures with the emphasis on powder and fiber methods rather than on single-crystal analysis. Considering the great academic and technological importance of structural investigations of polycrystalline and amorphous materials, and the analytical sensitivity and speed made possible by modern counting techniques, this book certainly meets a great demand. It is therefore most gratifying to note its high standard, both with respect to clarity of formulation and disposition and to the completeness in subject coverage.

The 55-page introductory chapter on elementary crystallography is outstanding in its concise, yet comprehensive form. A number of illustrative examples are given.

After chapters on the production and properties of X-rays, and on fundamental principles of X-ray diffraction, the authors enter into a detailed discussion of photographic and spectrometric powder techniques. The 81-page chapter on spectrometric techniques is of special interest, presenting and organizing material that has previously been scattered throughout the literature. This is true also for large parts of the chapters on interpretation of powder diffraction data and on qualitative and quantitative analysis of crystalline powders.

The last five chapters are devoted to special applications such as precision determination of lattice constants from powder photographs, crystallite size determination from line broadening, stress measurements in metals, fiber studies, radial distribution analysis, and small-angle scattering.

The text is illustrated by not less than 323 figures and the literature is covered by 663 references. The typography is of high quality. Minor details that may be criticized include the absence of references to some of the postwar work carried out in Germany, and the commonly seen but deplorable corruption of Anders J. Ångström's (pronounced *ongstrum*) name to angstrom, with the corresponding use of the mutilated symbol *A*. The authors express in their foreword the hope that the book may, with some measure of success, serve both as textbook and as encyclopedia for the plant worker, the graduate student, the research scientist, and others who wish to do experimental work in the field. The uniqueness and high quality of this text certainly guarantee the realization of the authors' hope.

GUSTAF ARRHENIUS

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● PHYSICAL PROPERTIES OF SOLID MATERIALS

C. Zwikker, **Director of the National Aeronautical Research Institute, Amsterdam. Interscience Publishers, Inc., New York, 1954. viii + 300 pp. Many figs. 16 × 24.5 cm. $8.75.**

A SUMMARY of the physics of solids within 300 pages is a courageous venture; how well the author has succeeded in reaching his stated goal depends on the demands of the reader. An expert in the field would probably complain that the book presents a mass of facts with few generalizations, that mathematical rigor is sacrificed for the sake of simplicity, and that the treatment of any one of the subtopics is superficial. The author, who is an expert in the field, anticipates these criticisms in his preface.

The book is intended for those readers to whom the subject as a coherent entity is essentially unfamiliar. Physical chemistry, especially experimental and applied, has many points of contact with the physics of solids, but most of the information is either mentioned incidentally in our standard books or else is completely ignored. To give a practical example, one of my students recently told me that he could not gold-solder the seam in a piece of platinum tubing which he had made by bending platinum sheet around a mandrel; the seam sprang open when he started to melt the gold. Work hardening and its obvious remedy evidently were completely unfamiliar ideas. The information he needed is in Zwikker's chapter on plasticity.

The author's style is clear and concise, and he displays an unusual ability in exposition, as can best be demonstrated by a few quotations. To explain why sulfur is an undesirable impurity in steel: "If iron or steel contains more than 0.02 per cent sulphur the latter will be in solution as FeS, which, because of its relatively low melting point (1188° C.) solidifies at a later stage of the solidifying process, thus enveloping the iron grains. The strength of the material is, therefore, the strength of FeS and not that of iron, so that the material becomes brittle. As a remedy manganese is added; this combines with sulphur even more readily than does iron, forming MnS with a melting point of 1620°C. This melting point is so high that MnS appears in the body of the grains, where it cannot play such an injurious role as it would if situated in the grain boundaries." To explain why metals are opaque: "Metals are opaque as a result of their electrical conductivity. Incident light, which is an electromagnetic wave, generates electric currents in the metal, as a result of which energy is consumed. Semiconductors of high conductivity are opaque for the same reason." To emphasize the significance of the structure of ice: "In practice the fourfold co-ordination of ice means that deep water remains at a temperature of 4°C., to the benefit of fish; that water pipes burst when the water in the pipes freezes; that water present in the cracks of rocks tends to split up the stone on freezing, thus contributing considerably to weathering processes, without which no fertile sedimentation in lowlands would be possible."

There is an amazing amount of information packed into this small volume, ranging from the mechanical properties of cork to an ingenious heuristic derivation of the Fermi distribution. Polishing of gems and the behavior of transistors, the pyroelectric effect of tourmaline and the ferroelectric properties of the titanates are other typical subjects. No detailed derivations are given; on the other hand, enough theory is included so that an interested reader knows where to go for further information. This book was not designed as a textbook for an elementary course in the physics of solids and naturally cannot be recommended as such. It can, however, be recommended as supplementary reading for a course in physical or advanced inorganic chemistry, and as a useful reference book for physical chemists, especially those who know how to compute the resonance energy of graphite but do not know why graphite fails as a lubricant on commutators in d.-c. generators on planes at high altitudes.

RAYMOND M. FUOSS

YALE UNIVERSITY
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• SUCCESSFUL COMMERCIAL CHEMICAL DEVELOPMENT

Edited by *H. M. Corley*, Armour and Company, Chicago. John Wiley & Sons, Inc., New York, 1954. xxv + 374 pp. Figs. and tables. 15.5 × 23.5 cm. $7.75.

"THIS book is a group effort. It was authorized and sponsored by the Commercial Chemical Development Association. It represents the thinking of many people. Each chapter... is the work of a committee and does not represent the method of operation of any company." Herein lies both the weakness and strength of the book. It deals in generalities, though occasionally reference is made to the operation of a specific company. With a corps of nearly 75 co-workers, Mr. Corley could have obtained interesting and illustrative examples galore, but apparently the chapter committees did not wish to praise or ridicule any company for its right and wrong commitments. The fable of how the Chinese learned to cook pork is discussed in connection with basic research. Are not there more appropriate examples?

Because the book is a group effort, each chapter does include a general view of the practice of the major chemical companies. In this way a new organization can select that part which best meets its needs, or the instructor in chemical economics can present a broad point of view to his students.

The need for a chemical marketing research group is firmly impressed on the reader, and then, in a broad way, the book follows the new chemical product from its inception to its bulk shipment. The problems of trade names, advertising, pricing, toxicology, safety, and the like are discussed from the point of view of the market development division.

Here is a book that will give much in chemical or chemical-engineering economics. It is too bad that the editors will not publish a case-history book of good and bad examples to accompany this book, to illustrate and stress the points being made.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

• GENERAL CHEMISTRY

W. Norton Jones, Jr., Professor of Chemistry, McMurry College Abilene, Texas. The Blakiston Co., Inc., New York, 1954. ix + 906 pp. 69 tables. 16 × 24 cm. $6.50.

THIS first-year college chemistry textbook is "suitable for use by groups composed both of students who have had high-school chemistry courses and of those who have not." As the title indicates, this is a *general* chemistry text, covering not only inorganic chemistry, but containing sections on atomic energy, organic, and colloid chemistry, with bits of analytical and physical chemistry interspersed.

Most of the theoretical material, such as atomic structure, periodic classification of the elements, states of matter, chemical equilibria, and so on, is found in the first half of the book, and constant references are made to it in the descriptive material, some chapters of which are interspersed in the first half of the book.

The usual procedure of studying oxygen and hydrogen early in the course is not followed. Instead, sodium and chlorine, as excellent examples of a metal and a nonmetal, are the first elements to receive consideration. Most of the elements, including oxygen, are studied as members of families, with the elements of the third period given first consideration because "these elements, besides showing periodic variations well, are of great industrial value and serve well to emphasize the practical aspects of chemistry."

The author realizes that the 900 pages of material cannot be covered in one year, and so especially the last half of the book is organized so that parts of chapters or whole chapters may be omitted or reordered without causing a serious break in the continuity.

The book, abundantly and excellently illustrated with drawings and pictures, is printed on high-grade slick paper. Appended to each chapter is a list of book and periodical references, and a series of exercises. The exercises, consisting of questions, problems, and equations, are extensive and varied, giving the instructor a wide choice of material.

This text is written to suit a variety of needs and certainly should be examined for class adoption by the many schools who still teach *general* chemistry to freshmen. If not used as a text it will serve as an excellent reference book for freshmen and more advanced undergraduates.

H. A. MEYER

CONCORDIA TEACHERS COLLEGE
SEWARD, NEBRASKA

• COMPREHENSIVE INORGANIC CHEMISTRY. VOLUME 3: THE HALOGENS

Robert C. Brasted. Edited by *M. Cannon Sneed, J. Lewis Maynard,* and *Robert C. Brasted,* University of Minnesota. D. Van Nostrand Co., Inc., New York, 1954. x + 250 pp. Tables. 16 × 23.5 cm. $5.

THIS book by Professor Brasted emphasizes the descriptive chemistry of the halogens with no attempt at being an exhaustive or advanced treatise. There results from the distillation of the voluminous literature on this subject a well rounded perspective of the chemical and physical behavior of the halogens. Modern structural theory is used to elucidate the often perplexing properties of this group.

The elemental properties of fluorine, chlorine, bromine, iodine, and astatine are initially treated, followed by chapters on the hydrohalides, the oxycompounds, the positive halogens, the interhalogens, and polyhalide complexes. Having developed the "halide character" the author logically enters the domain of the nonhalogen-containing pseudohalogens to conclude the book. There is a liberal sprinkling of historical, geological, and industrial aspects of halogen chemistry which enhance the readability of the volume.

The book, like its two predecessors, will probably serve more as collateral reading in advanced undergraduate courses in inorganic chemistry than as a reference book on the research chemist's shelf. Nevertheless, the practicing chemist who has lost contact with the halogens will be rewarded by a perusal of such topics as the relationship of color to iodine chemistry and the properties of astatine.

EDWARD D. GOLDBERG

SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

● ORGANIC SYNTHESES. VOLUME 34

Edited by *William S. Johnson.* John Wiley and Sons, Inc., New York, 1954. vi + 121 pp. 15.5 × 23.5 cm. $3.50.

THIS latest addition to the well known annual series brings together the work of 62 contributors and deals with 36 important syntheses. Volume 34, like the previous volumes, contains the most convenient methods for preparing a wide variety of organic chemical reagents. All the reactions discussed have been carefully checked and tested by leading chemists throughout the country. This volume again gives the equations for the reactions and procedures for production with accompanying notes and other methods of preparation.

Preparations are listed under common names and *Chemical Abstract* names for: 2-*p*-acetylphenylhydroquinone, azelanitrile, β-(*o*-carboxyphenyl)propionic acid, cetylmalonic ester, 2-chloro-1,1,2-trifluoroethyl ethyl ether, cycloheptanone, cycloheptanone, di-*tert*-butyl malonate, 3,4-dihydro-2-methoxy-4-methyl-2H-pyran, 9,10-dihydrophenanthrene, *p,p'*-dinitrobibenzyl, 1,4-dinitrobutane, dimethylfurazan, diphenylacetylene, diphenyl succinate, ethoxyacetylene, ethyl chlorofluoroacetate, ethyl enanthylsuccinate, ethyl β, β-pentamethyleneglycidate, hemimellitene, *o*-methylbenzyl alcohol, 2-methylbenzyldimethylamine, *N*-methyl-1,2-diphenylethylamine and hydrochloride, methylisourea hydrochloride, 3-methyl-1,5-pentanediol, 3-methylthiophene, phenanthrenequinone, 1-phenylpiperidine, *o*-phthaldehyde, sodium β-styrenesulfonate and β-styrenesulfonyl chloride, tetralin hydroperoxide, *p*-toluenesulfinyl chloride, *p*-tolylsulfonylmethylnitrosamide, and *o*-xylylene dibromide.

The cumulative subject index comprises all material contained in Volumes 30 to 34 inclusive, all previous preparations having been tabulated in Collective Volumes 1 and 2, and Volume 29. It is hardly necessary to elaborate on the value and service rendered by these unique volumes. They remain supreme among American releases of their type. Organic chemists have learned to purchase each volume almost by habit. This latest volume again conforms completely in size, style, appearance, and quality with all previous releases in the series.

RALPH E. DUNBAR

NORTH DAKOTA STATE COLLEGE
FARGO, NORTH DAKOTA

● FLUORESCENCE ANALYSIS IN ULTRAVIOLET LIGHT

J. A. Radley and *Julius Grant.* Fourth edition. D. Van Nostrand Company, Inc., New York, 1954. xvi + 560 pp. Illustrated. 14.5 × 22 cm. $12.

THIS new edition of a well known work seems well justified. The decade and a half since the third edition brought many improvements in apparatus, technique, and applications. To incorporate all the necessary changes necessitated extensive rewriting and considerable addition of new material. The wealth of original literature now covered on this kind of fluorescence analysis is shown by some 3500 references cited.

The five chapters of Part I (111 pp.) deal chiefly with the technique of producing ultraviolet radiant energy, isolating certain spectral regions, measuring its intensity, and applying it for analytical purposes. As might be expected, British instruments are emphasized.

Then the twenty chapters of Part II (413 pp.) deal with a variety of applications ranging from agriculture to waters. Fundamentally, most of these kinds of application are either qualitative or quantitative. In the former, the occurrence of fluorescence under given conditions is (usually) taken to indicate the presence of some substance. In the latter, the intensity of the emitted light is taken as a measure of the amount of a desired constituent. Forty-five photographic prints (black and white) are included.

The reviewer prefers to limit the word "light" to the visible region of the spectrum, as recommended by the colorimetry committee of the Optical Society of America. Also, the term "fluorescimeter" seems preferable to "fluorimeter," as the latter might imply an instrument to determine fluorine.

Altogether, this monograph seems most valuable as a reference source showing the large number of interesting applications of fluorescence phenomena.

M. G. MELLON

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

● BASIC GENERAL CHEMISTRY IN OUTLINE FORM

***E. L. Haenisch,* Professor of Chemistry, Wabash College, and *G. N. Quam,* Professor of Chemistry, Villanova College. Fifth edition. Burgess Publishing Co., Minneapolis, 1953. v + 285 pp. Many figs. and tables. 22 × 27 cm. Paper bound. $4.**

THOSE who teach elementary chemistry face a formidable task, fortunately balanced by equally great aesthetic and intellectual rewards. And perhaps the greatest difficulty which faces those charged with the responsibility of instructing neophytes in the art and science of chemistry is how to best aid them in efficiently, intelligently, and effectively studying their subject.

Usually, since they are freshmen, they are eager enough to learn; but very quickly many become disillusioned simply because they start out on the wrong foot—trying to memorize everything the book states and the instructor says, failing to see, or even to look for any logical order whatsoever. These students badly need some way to determine what is important and what is explanatory in nature and therefore safely forgotten once the principle illustrated is well in mind in its proper ordered place.

The text in review will certainly help the bewildered student to distinguish the important from the unimportant and to place the several independent concepts and principles in an ordered whole. It is more than just a handbook to help the student solve problems; it is a complete *outline* of the material discussed in an elementary course in chemistry. The topical order conforms well enough with any typical text of general chemistry to be useful. In those cases where the order of presentation varies considerably from that used by a text, the enterprising student will have no difficulty in using the assistance offered by the outline. It would seem that the outline could be used as the primary aid to a text, much as the problem-solving handbooks are now used, but to greater advantage; or the outline could itself serve in place of a text, the students being referred to a standard text for further information. The six appendixes include either a text-like or tabular presentation of exponential notation, approximate answers, how to use a slide rule, atomic weights, valences of the very common elements, etc. The book is printed legibly and neatly by the photo offset process; it is bound with a wire spiral. Because of its great potential usefulness to every freshman chemistry student, it seems a pity that the price is only a little less than that of the standard text which the student should also buy. But, on the other hand, if we consider this same utility as a purchasable commodity, our students have a bargain here, indeed.

JAY A. YOUNG

KING'S COLLEGE
WILKES-BARRE, PENNSYLVANIA

● LABORATORY PRACTICE OF GENERAL CHEMISTRY

***G. N. Quam,* Professor of Chemistry, Villanova College, and *E. L. Haenisch,* Professor of Chemistry, Wabash College. Fourth edition. Burgess Publishing Co., Minneapolis, 1954. viii + 170 pp. 22 × 27 cm. Paper bound. $3.**

THE authors assert that the laboratory is the proving ground for the student. It is certain that this manual will be as effective in accomplishing the aims implicit in this assertion as any other

good laboratory manual. The order of experiments corresponds with the order of presentation in "Basic General Chemistry in Outline Form," by the same authors.

Duplicate report sheets are provided, one with perforations for easy removal and presentation for grading. (The use of carbon paper is suggested.) Emphasis is placed on the use of the balance, qualitative (macro and semimicro) analysis, and on well chosen demonstrations by the instructor. Useful information is tabulated in eight appendixes.

JAY A. YOUNG

KING'S COLLEGE
WILKES-BARRE, PENNSYLVANIA

• STATISTICAL ANALYSIS IN CHEMISTRY AND THE CHEMICAL INDUSTRY

Carl A. Bennett, Chief Statistician, General Electric Co., and *Norman L. Franklin,* Lecturer in Chemical Engineering, University of Leeds, England. John Wiley & Sons, Inc., New York, 1954. xvi + 724 pp. Many figs. and tables. 15.5 × 23.5 cm. $8.

THIS book was written under the sponsorship of the Committee on Applied Mathematical Statistics of the National Research Council. Following the goals suggested by this committee, it contains, a "mathematically complete development of those aspects of mathematical statistics most useful to chemists and chemical engineers."

The appropriate fundamentals of the subject are presented in the first five chapters, the first third of the book. This section reads like a textbook in mathematical statistics with brief examples using chemical data. Certain purely mathematical subjects, *e. g.*, permutations, gamma and beta functions, are treated in appendixes to the chapters. The last two-thirds of the book continues in terse mathematical style and carries the development to the various important special methods, *e. g.*, analysis of variance (160 pp.), design of experiments (120 pp.), regression, and control charts.

Looked upon as a text, this book is suitable for a two-semester course at the graduate or senior level, with the first semester devoted to fundamental concepts and the second to applications.

Chemists who have a working knowledge of statistics acquired randomly from handbooks and through contact with practical statistical treatments will wish to study this book systematically. As reward for his effort the experimenter who does this will find the character of his interpretation of data removed from subjectivity and ritual to objectivity and system, soundly conceived and tailored to the case at hand. Valuable by-products will be increased efficiency through proper design of experiments, and clearer and more accurate presentation and communication of results.

RALPH A. JOHNSON

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

• NUCLEAR THEORY

Robert G. Sachs, Professor of Physics, University of Wisconsin. Addison-Wesley Publishing Co., Inc., Cambridge, Mass., 1953. xi + 383 pp. Figs. and tables. 16 × 24 cm. $7.50.

AS IS to be expected of a modern book on nuclear theory, this work will only be intelligible to those with some background in the methods and terminology of quantum mechanics. There are two, short introductory chapters which do not have this restriction, but the material covered there can be obtained in amplified form in other works on nuclear physics devoted to a more descriptive treatment.

In an effort to keep the book down to fairly modest size the author has omitted treatment of a number of topics of current interest. He has placed primary emphasis, in a series of coordinated chapters, on the interaction of elementary particles, the major example of which is the properties of the deuteron as they relate to the proton-neutron interaction. As stated by the author, this approach is taken because these problems are basic in the development of nuclear theory and because their detailed discussion illustrates well a number of the analytical methods used more generally.

Aside from the chapters mentioned above, which make up about one-half of the text of the book, there are others which deal in more cursory fashion with the structure of complex nuclei, nuclear reactions, beta decay, and electromagnetic interactions of nuclei. These will probably be found to be inadequate for those who want a comprehensive treatment of the subjects.

The book was designed as a text for an introductory graduate course in nuclear theory. It should serve this purpose well, with its emphasis on the simplest nuclear systems. As already mentioned, it does not give an over-all picture of what has been learned about more complex systems.

I. PERLMAN

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

• RECENT PROGRESS IN HORMONE RESEARCH VOLUME 10

Edited by *Gregory Pincus.* Academic Press, Inc., New York, 1954. 511 pp. 134 figs. 16 × 23 cm. $9.80.

THE proceedings of the Laurentian Hormone Conference held in Quebec in September, 1953, make up the content of this book. The reader may feel assured that the topics presented as papers at this meeting and the discussions which follow each paper reflect the latest knowledge and points of view, up to the date of the conference, of the topics that were considered.

The material has been grouped under six general headings: I, Nervous System—Hormone Interrelationships; II, Thyroid Hormone Physiology and Biochemistry; III, Comparative Endocrinology; IV, Protein Hormones; V, The Role of Hormones in Blood and Blood-forming Organs; VI, Aspects of Clinical Endocrinology. Two or three chapters were presented under each of these general topics and with the discussions make up the 14 chapters in the book. Including the 28 authors and discussors, about 100 investigators participated in the conference and their remarks are recorded in full.

The chemist will find certain chapters of more interest to him than others which may be remote from his professional experience. Among such are the chapters on the chemistry of insulin, the chemistry of the corticotrophins, and thyroid physiology and biochemistry.

The contributions that newer chemical techniques have made in the separation of individual hormones and their metabolic products or toward the elucidation of hormone interrelationships is evident in all the topics presented. In spite of the progress that has been made the reader will be impressed with the complexities of the problems that still confront endocrinologists.

F. A. CAJORI

UNIVERSITY OF COLORADO
DENVER, COLORADO

• PROTEIN METABOLISM

R. B. Fisher, Demonstrator in Biochemistry, University of Oxford. John Wiley & Sons, Inc., New York, 1954. ix + 198 pp. 24 figs. 15 tables. 11 × 17 cm. $2.50.

DR. FISHER'S contribution to Methuen's Monograph Series is a nugget of gold. Any biochemist whose interest touches on protein metabolism owes it to himself to read the book. There

are many who will feel that the author is hypercritical; some will resent his thoughtful reinterpretation of published data, others will feel a sense of shock as one after another of the most commonly held theories is ingeniously attacked. I do not doubt that some would rather like just this once to burn a heretic at the stake.

Specifically, Dr. Fisher can be charged with such vandalism as: (1) casting doubts on the absorption of protein nutrients as free amino acids, (2) doubting free amino acids to be the legal currency in protein metabolism, (3) threatening to reject the current Krebbs ornithine cycle as a source of urea in metabolic processes, (4) insisting on caution in interpretation of data obtained using isotope-labeled amino acids, (5) citing evidence that so called "glycogenic" amino acids are not sources of carbohydrate. He amply proves what a "nuisance" a person can be if he is allowed to think. Although his arguments may be disagreed with in one or another detail I doubt that any good scientist can emerge from reading this book without having become the better for it. The unifying theme is that protein metabolism is concerned with the metabolism of amino acids in concert, a process regarded by the author as something distinct from the metabolism of the individual amino acids. This point of view is incompatible "with the notion that the major processes of protein metabolism can be profitably studied by investigating the fate in the organism of individual amino acids."

For all of the value attached to the technical aspects of the book it is the reviewer's opinion that something more lasting is contained. This stems from the classical approach to the problem which is particularly notable in the writings of some British scientists and so woefully lacking on this side of the Atlantic. A few quotations from the book will illustrate the fact that the author is something far more significant than a chemist: "...the approach selected...places emphasis on the structure of scientific advance. It is a matter of importance that what is newer in the way of scientific conclusions can only be better if the interpretations placed on the newer facts are based on sound interpretations of earlier facts. It is not always realized that interpretations are based more often on considerations of relative plausibility than of logical necessity, and that which constitutes relative plausibility is to a large extent a matter of current fashion in abstraction.... The major pleasure of scientific research is in the creation of successful working hypotheses, but the affection their authors tend to conceive for such creations can be dangerous: Like Galatea, the hypothesis comes to have a life of its own."

Considerations of this sort teach us how much more readily we, as scientists who claim to know better, take to living by faith rather than by verification. At times our blind acceptance of hypotheses as constituting objective truth calls for such a tremendous act of faith as would make a theologian shudder. Dr. Fisher says: "This book owes its inception to Professor Sir R. A. Peters, F.R.S. Any virtues it possesses are the outcome of his teaching, his encouragement, and his critical comments." This tribute makes one wish that there were more such teachers as Sir Rudolph everywhere.

ELIOT F. BEACH

METROPOLITAN LIFE INSURANCE COMPANY
NEW YORK, N. Y.

● ABNORMAL AND PATHOLOGICAL PLANT GROWTH

***Biology Department,* Brookhaven National Laboratory, Upton, New York, 1954. vii + 303 pp. Figs. Tables. 18 × 25.5 cm. Paper bound. $2.10. (Available from Office of Technical Services, Department of Commerce, Washington 25, D. C.)**

EACH year, the Brookhaven National Laboratory organizes a series of conferences on some biological subject of interest. This volume is sixth in a series which has ranged from "Biological Applications of Nuclear Physics" (No. 1) to "The Major Metabolic Fuels" (No. 5) in previous years. It deals with conferences held from August 3 to 5, 1953, on the subject "Abnormal and Pathological Plant Growth."

This volume is composed of a series of papers presented at the conferences, together with illustrative material, references, and records of the informal discussions which followed each paper. The topics covered include development of plant parts in tissue culture, morphogenetically active substances, genetic tumors, crown gall, experimental inhibition of plant tumor growth, viruses and virus-induced abnormalities, root nodules, insect galls, and abnormalities induced by ionizing radiations.

Judging from the lucidity of certain of the papers and the interesting discussions which followed, this must have been an informative and enjoyable symposium. Especially interesting to the present reviewer were the contributions of F. Skoog, R. M. Klein, A. C. Braun, R. S. de Ropp, J. E. Gunckel, and A. H. Sparrow.

Although the book will be of interest mainly to those who work in plant physiology or pathology, its perusal will reward biochemists and general biologists as well. Unfortunately, it has been wrapped in an insubstantial paper cover and held together by three large staples. It deserved a better fate.

ARTHUR W. GALSTON

CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

● MOLECULAR THEORY OF GASES AND LIQUIDS

***Joseph O. Hirschfelder, Charles F. Curtiss,* and *R. Byron Bird,* Departments of Chemistry and Chemical Engineering, and the Naval Research Laboratory, University of Wisconsin. John Wiley & Sons, Inc., New York, 1954. xxvi + 1219 pp. Illustrated. 15.5 × 23.5 cm. $20.**

PRIOR to the publication of this book, anyone seeking to learn the present status of our understanding of the thermodynamic and transport properties of fluids—gases and liquids—would have had to read fragmentary or out-of-date discussions in a dozen books, fifty to a hundred articles in recent journals, and the reports of the University of Wisconsin Naval Research Laboratory. In this volume the authors, with the assistance of the staff of the Naval Research Laboratory, have brought together virtually all the existing theories of gases and liquids and of the intermolecular forces which give rise to their properties, and have presented them in a clear and logical manner. Theirs was a monumental task and they have been remarkably successful in achieving their aim.

Since the high price may induce at least temporary paralysis in the mind—or pocketbook—of the individual student, teacher, or researcher, it is well to recognize that the cost is only 1.61 cents per page, better than average in the present period of skyrocketing publishing costs. (A recent monograph with which this reviewer was associated now sells for 2.41 cents per page.)

The book is really three volumes in one. The first 400 or so pages are devoted to the equilibrium properties (*i. e.*, statistical thermodynamics) of gases and liquids—equations of state, virial coefficients, various simple models for dense gases and liquids, vapor-liquid equilibrium and critical phenomena, and quantum effects at low temperatures. The second 400 pages discuss nonequilibrium (transport) properties of gases and liquids—viscosity, diffusion, and thermal conductivity—using kinetic theory and nonequilibrium statistical mechanics. Nearly 300 pages are devoted to a detailed review of the classical and quantum-mechanical theory of intermolecular forces. In conclusion, the authors give 72 pages of computed values of a wide variety of properties, which will be invaluable in comparing experimental data with theory.

The authors' treatment is primarily theoretical and many readers will wish there were more comparison with experimental data. Many comparisons are given, and where they are lacking, as in much of the work on liquids, experimental data are fragmentary or nonexistent. Even so, it seems reasonable to criticize

the authors for spending many pages on the very inadequate and unsatisfactory "free volume" theory of liquids (refinements of the original work of Lennard-Jones and Devonshire) and neglecting almost completely the admittedly semiempirical corresponding states treatment which Pitzer and Guggenheim gave for simple fluids ("perfect liquids") like argon and methane.

The publisher's advertising suggests this book as an up-to-date text for advanced courses. While most teachers will be reluctant to require students to purchase a twenty-dollar text, they can certainly recommend, at least for library reading, a book so well designed for student use. The authors have been very careful with their use of symbols and difficult mathematics; the derivations and general discussions, while not always easy, are remarkably lucid.

As a reference work, this is almost unsurpassed. In spite of the difficult nature of the subject it is fairly easy to open to a subject in the middle of the book and understand it with a minimum of wasted effort. Some reference to previous sections is, of course, inevitable, but this is kept to a minimum and back-references are always clearly stated. No person doing research in any of the fields covered can afford to be without this volume at his finger tips.

ROBERT L. SCOTT

University of California
Los Angeles, California

• PROBLEMS IN ORGANIC CHEMISTRY

Edward G. Rietz, **Wright Junior College, and** ***Cash B. Pollard,*** **University of Florida. Prentice-Hall, Inc., New York, 1953. vii + 332 pp. 13.5 × 21.5 cm. $3.95.**

This is the first book of problems in organic chemistry in twenty years or more. Most teachers of elementary organic chemistry agree that there is no better way for a student to make the new language and myriad details of organic chemistry a part of himself and to become aware of the interrelationship of classes of organic compounds than to solve many and different types of problems.

The book contains 29 chapters, an answer section, a list of "name" reactions, references, and an adequate index. The first 28 chapters are arranged according to classes of organic compounds in the classical order of most organic textbooks. Each chapter is headed by an excellent systematic discussion of nomenclature stressing the I. U. C. but including also other systems and common names. Then a short outline of the methods of preparation, physical properties, and reactions of the class of compounds under treatment is presented and followed by a series of problems. These problems illustrate (1) naming of organic compounds; (2) writing formulas from names; (3) preparative methods; (4) syntheses; (5) balancing of oxidation-reduction equations by a simple method of equating the electron change for the number of oxygen atoms theoretically necessary to oxidize one molecule of the compound to the electron change of the specific oxidizing agent used; (6) determination of structure from quantitative and qualitative data entailing a review of the calculations of inorganic, qualitative, and quantitative chemistry; (7) methods of distinguishing organic compounds; and (8) some of the theoretical aspects of the science. Chapter 29 consists of 80 identification or structure problems of varying degrees of difficulty. All of the problems are answered concisely in an answer section following Chapter 29. Enough explanation is given in each answer to enable the student to follow clearly the reasoning of the authors and to edit his own accordingly.

The answers to some of the problems depend only on material included in this book, but to solve many of the problems the student is forced to refer to his own and other textbooks, to tables of physical constants, and to other reference books. The "name" reactions list which precedes the index is a helpful guide in this connection.

The book contains many typographical errors and some omission of words. In most cases, the meaning is clear despite the errors. However, when ethene, sulfonic, and benzamide should read, respectively, ethane, sulfinic, and benzanilide, understanding is impaired. Subscripts are hard to read and 6 and 8, or 3 and 8 can be confused. Greek-letter prefixes are poorly printed. The plus and minus signs on structural formulas of ionic compounds often are carelessly placed. The factual material is accurate and up to date. However, the treatment of electron mechanisms is highly attenuated and when attempted somewhat vitiated by poor formula illustration.

It is probable that no book on problems can or ever will satisfy entirely the needs of any teacher other than the authors. However, the problems included in this book are general in application, varied in type, and cover the usual material of the first-year organic course well. Many college or junior-college teachers and serious students of organic chemistry will find the book useful. I find it a distinct advantage to introduce my students to problems whose emphasis and wording differ from mine and those of the textbook in current use.

INA M. GRANARA

Simmons College
Boston, Massachusetts

• THE CHEMICALS OF LIFE: ENZYMES, VITAMINS, HORMONES

Isaac Asimov, **Boston University School of Medicine. Abelard-Schuman, New York, 1954. 159 pp. Illustrated. 14 × 21 cm. $2.50.**

As indicated in the title, this book is about some of the substances that make life possible. You will see that the enzymes, together with their helpers, the vitamins and hormones, control the different reactions in our bodies and make certain that all the ingredients in the cells are working properly. You will learn how an enzyme works, how chromosomes split up and reunite, how food protein is changed to human protein, the importance of vitamins, the glands where hormones are manufactured, and many more things about enzymes and body chemistry. Dull? Dr. Asimov is a man of many talents. "The Chemicals of Life" is nonfiction, strictly accurate, and scientific, but as fascinating to read as any of his science fiction.

GRETA OPPE

Ball High School
Galveston, Texas

• GMELINS HANDBUCH DER ANORGANISCHEN CHEMIE. SYSTEM 62: GOLD. PARTS 2 AND 3

Edited by ***Erich Pietsch.*** **Eighth edition. Verlag Chemie, GMBH, Weinheim, Germany. Part 2: v + 306 pp. 17.5 × 25.5 cm. $40.32. Part 3: xxi + 558 pp. 17.5 × 25.5 cm. $74.88. (Available through Walter J. Johnson, Inc., 125 E. 23rd St., New York 10, N. Y.)**

The publication of Parts 2 and 3 of the volume on gold completes the work on that element. The first part, which was published four years ago, was devoted to the history of gold and its influence on civilization. Part 2 is divided into four chapters, the first of which (178 pages) discusses the occurrence of gold in celestial bodies, in many parts of the earth's crust, and in the sea, and includes data on the production of gold throughout the world. The second chapter (69 pages) is devoted to the various mechanical, chemical, and metallurgical processes that are used in winning gold from its ores, and in its purification. The third chapter (54 pages) describes the preparation of special modifications of the metal (foil, powder, crystals, and colloidal gold) and the separation of the isotopes of gold, while the final, short chapter (5 pages) describes the surface treatment of gold and its alloys.

At the end of World War II it became necessary for the editors of "Gmelins Handbuch" to omit chapters on the detection and es-

timation of the elements, and none of the volumes published since that time has contained such chapters. With the publication of the work on gold, however, the inclusion of analytical methods is renewed—a change which will be welcomed by all chemists. In addition to this chapter (24 pages), Part 3 contains very complete discussions of the physical properties of gold (143 pages), its electrochemical behavior (57 pages), and its reactivity toward many types of chemicals (23 pages), as well as a very short chapter (1 page) on its physiological action. The preparation and reactions of gold compounds are then discussed in some detail (112 pages) and the volume is completed with a chapter on the alloys of gold (192 pages). Since most of the gold of commerce is used in the form of alloys, these have been the subjects of much research, and they are treated here at some length. Gold is usually alloyed with copper or silver to improve its hardness and mechanical properties, and the alloys with these metals are therefore treated in the greatest detail. The amalgams, which are important in the metallurgy of gold, also receive detailed treatment.

These books, like others in the Gmelin series, are of necessity expensive, but they are essential to every chemical library.

JOHN C. BAILAR, JR.

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● MICRO AND SEMIMICRO METHODS

Nicholas D. Cheronis, **Professor of Chemistry, Brooklyn College. Volume VI of "Technique of Organic Chemistry," edited by *Arnold Weissberger.* Interscience Publishers, Inc., New York, 1954. xxiii + 628 pp. 221 figs. 41 tables. 16 × 24 cm. $12.**

IN THE introduction to the three main parts into which this book is divided, the development of microchemistry is traced, the terminology is discussed, and the advantages and applications of microchemical techniques are pointed out. Teaching aspects are by no means overlooked; despite the obvious economies in materials and other advantages made possible by the adoption of micromethods, Professor Cheronis expresses the opinion that students should be introduced gradually to such methods.

Micro and semimicro techniques for such general operations as crystallization, distillation, sublimation, extraction, etc., are extensively discussed in Part I, together with such determinations as those of melting point, density, molecular weight, etc. From the outset, the highly practical nature of this book is apparent; although the numerous forms of apparatus available for a given purpose are critically reviewed, detailed description is usually limited to one or two. These are generally either easy to make or are available commercially. The value of the microscope, both in the determination of melting point and in the study of fusion phenomena, is pointed out and, in discussing the calibration of thermometers, the author draws attention to the scarcity of accurate melting-point data on organic reference standards.

Preparative reactions are described in Part II, micro and semimicro methods for oxidation, reduction, halogenation, and other important operations being given. These are illustrated by selected preparations, for which full details, including yields, are given. Frequent reference is made to the hitherto unpublished work of the author and his co-workers and many simple tips, such as the pre-treatment of a rubber stopper for a bromination apparatus, and the "on the spot" preparation of 100 per cent nitric acid, anhydrous aluminium bromide, etc., are neatly woven into the text. A chapter contributed by Dr. A. R. Ronzio describing microsynthesis with tracer elements provides a perfect illustration of a branch of chemistry in which microtechniques are indispensable.

Analytical procedures and reactions are the concern of Part III, which is subdivided into three main sections. The first of these deals with the characterization of organic compounds. Schemes for identification are discussed and procedures for preliminary examination and for the detection of elements are described. Instructions for the performance of more than 40 tests for the various functional groups are given in the second section, which concludes with a brief description of the application of physical methods to the detection of such groups. Directions for the preparation of derivatives are given in the third section, in which the importance of such factors as the purity of reagents, ratio of reactants, crystallization procedure, etc., is clearly illustrated by examples. The various classes of organic compounds are then dealt with in turn. Each chapter opens with a critical discussion of the various possible reagents and derivatives, and gives full instructions for the use of the reagents selected, and for the preparation of typical examples of derivatives. A brief final chapter, written in collaboration with Dr. T. S. Ma, deals with quantitative micromethods for the estimation of functional groups, a field in which much work still remains to be done. Not the least interesting portion of this chapter is the description of a project, now under way, for the critical evaluation of micro and semimicro techniques for a large number of such estimations. As indicated in the preface, elementary quantitative analysis is not dealt with.

Excellently illustrated and including some 2000 literature references, this book should appeal to an unusually wide range of readers. Although intended for research workers and advanced students, it could be read (and *used!*) by those whose interests in practical organic chemistry are at a more moderate level. The style is clear and the spirit of inquiry which runs right through is very infectious.

JOHN T. STOCK

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● ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY. VOLUME XIII: STILBITE TO THERMOCHEMISTRY

Edited by *Raymond E. Kirk* and *Donald F. Othmer,* Professors and Heads, Departments of Chemistry and Chemical Engineering, respectively, Polytechnic Institute of Brooklyn. Assistant editors, *Janet D. Scott* and *Anthony Standen.* The Interscience Encyclopedia, Inc., New York, 1954. xvi + 952 pp. 19 × 27 cm. Single copy price, $30. Subscription price, $25.

WHAT important and interesting subjects appear in the interval from *Stil-* to *Thermo-* ? Sulfur, sugars, terpenes, and textiles, with their ramifications, dominate the interval. There must be other subjects, which certainly are more than space fillers.

The inorganic chemist will find the elements strontium, tantalum, tellurium, thallium, and their compounds. In addition to the element sulfur is its inorganic compounds, sulfuric acid, sulfur trioxide, and sulfamic acid. Organic sulfur compounds occupy a large section, with other topics such as organic sulfides, sulfinic and sulfonic acids, sulfones, sulfonamides, sulfa drugs and sulfur dyes. Succinic and tartaric acids have small sections. Terpenes and terpenoids are treated in some detail—acyclic, cyclic, sesqui-, di-, and tri- types of compounds. Sugars are treated as a chemical group and also the members produced commercially for various uses.

The biochemist finds several important subjects: stimulants and depressants of the nervous system, streptomyces and antibiotics, and the tetracyclines.

The physical chemist has the important subject of surface properties and thermochemistry, as well as thermal analysis. The chemical engineer finds stoichiometry, the unit process of sulfonation and sulfation, as well as temperature measurement.

The various industries and technologies run from the natural to the synthetic. Sugar and textiles dominate the subject. The manufacture and analysis of sugars cover sucrose in detail and also the other commerical sugars. Textile fibers are surveyed in general, but the acrylic, vinyl, polyester, tetrafluoroethylene, and glass fibers are discussed in detail. The general fields of textile technology and testing cover the preparation and treating of the cloth from the fibers. Other important subjects are styrene

and its resins and plastics, surface-active agents, sweetening agents, talc, tall oil, tar and pitch, and tea.

E. C. T. should become a completed entity in 1955. This is an event to which we can look forward. We can begin to wonder what the staff has in store in the way of augmenting the present material and topics.

KENNETH A. KOBE

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• CHEMICAL ENGINEERING. VOLUME I

J. M. Coulson and *J. F. Richardson*, Imperial College of Science and Technology. McGraw-Hill Book Co., Inc., New York, 1954. viii + 370 pp. Figs. and tables. 16 × 23.5 cm. $7.50.

THIS English text is the first of two volumes making up a new entry into the field of general textbooks covering the unit operations of chemical engineering. Volume I covers fluid flow, heat transfer, and mass transfer, and the relationships among these as the fundamental mechanisms of the rest of the unit operations. It is understood that Volume II will apply these theoretical foundations to distillation, filtration, evaporation, etc.

Section *A* of the first volume has the usual chapters on friction in pipes, flow measurement, and pumps. Section *B* is a rather condensed chapter on heat transfer including conduction, convection, and radiation. Section *C* is a general introduction to mass transfer with a chapter on diffusion, a chapter on the relationships among heat, momentum, and mass transfer, and one on the boundary layer. The latter contains mathematical treatments not usually included in first-year chemical engineering courses in this country. Section *D* contains one chapter on humidification and cooling as a practical example of simultaneous heat and mass transfer.

The authors have made a good presentation of standard first-year unit-operations material. The mathemetical treatments are often given in more detail than usual. They have adopted the technique, however, of putting what they consider to be the more difficult theoretical treatments in small type.

Most of the necessary charts and tables for the working of problems are included, but many of them are quite small and the book in general is not as profusely illustrated as others in this field. Worked examples appear in each chapter, and the publishers state that a selection of problems will appear at the end of Volume II.

S. RICKLIN

RICKLIN RESEARCH ASSOCIATES
PROVIDENCE, RHODE ISLAND

• BIOCHEMISTRY

Abraham Cantarow, Professor of Biochemistry, and *Bernard Schepartz*, Assistant Professor of Biochemistry, Jefferson Medical College. W. B. Saunders Co., Philadelphia, 1954. xxv + 848 pp. 136 figs. 75 tables. 16 × 24 cm. $11.

THIS thoroughly excellent new text in biochemistry, according to the authors, is designed primarily to meet the needs of the first-year medical student. It is the opinion of the reveiwer that something rather more fundamental than this limited objective has been achieved. The text is worthy of the more serious student of the science and should find much wider application wherever biochemistry must be taught in its modern detail.

In reading the book one is amazed at the tremendous progress which has taken place in all phases of the subject in the past few years. The medical student is now called upon to comprehend a mass of material in biochemistry alone which seems almost staggering. The authors say: "Although biochemistry currently occupies a focal position in all of the medical sciences, as well as in clinical medicine, this is the one subject in the medical curriculum that the average student is not adequately equipped to grasp readily in the form in which it is usually presented." Presumably the authors were going to amend the situation and change the form. While they have done a fine job of presentation and made some innovation, it is the reviewer's opinion that the subject material has not thereby become a "pushover" for the average medical student. The prediction remains that medical students will still be, as a general rule, of rather low competence in this field, and that serious biochemistry will have to be left more and more to the specialist. The most hopeful aim for medical education in biochemistry can only be to give a general over-all picture of some dynamic aspects of biochemistry. This the book is able to do well. In going even further the text will still leave the poorly grounded medical student feeling out over his depth.

Worthy of note are the chapters on Metabolism of Carbohydrates, Lipids, and Proteins. This increasingly complex and fascinating material is presented with magnificent clarity. A very extensive treatment of the hormones is a noteworthy achievment. The text is quite readable, the developments are logical, and of special appeal is the fact that each chapter has a general discussion at the outset explaining wherein the material of that chapter is important to the student. The tone is positive throughout and this is achieved because controversial points are not belabored. All of these attentions help the beginner in getting a grasp on the subject.

The bibliography is more than adequate for the average student. The references are wisely confined to review materials and broad presentations. Most remarkable is the multitude of figures mainly designed to show the metabolic fate of materials. They achieve a swoop and flourish that makes the dynamic state of living tissue seen more credible than ever.

ELIOT F. BEACH

METROPOLITAN LIFE INSURANCE CO.
NEW YORK, N. Y.

• TECHNIK DER EXPERIMENTALCHEMIE

Rudolf Arendt and *Ludwig Dörmer*. Sixth edition, completely revised by *K.-E. Dörmer*. Quelle and Meyer, Heidelberg, 1954. xvi + 439 pp. 231 figs. 16 × 23.5 cm. DM 35.

THIS book represents not merely the revision of a work which has passed through a number of previous editions, but rather constitutes a rejuvenation of a reference book which over 30 years ago was considered a standard text. The preceding, fifth edition appeared in 1924; in the intervening years Ludwig Dörmer, father of the present chief author, Karl-Edmund Dörmer, passed away, and the task of completing the revision of the book after the manner set by the elder Dörmer fell upon the son. Furthermore, the delay in this task was to a considerable extent increased because of the after-effects of the last war.

The new edition contains a general part of some 88 pages with numerous literature references, which is intended to point out the importance of chemical experimentation and its historical development. The significance of the experimental side of chemical instruction, both in the form of laboratory experiments performed by the student and those carried out by the instructor as lecture demonstrations, is emphasized throughout the book. Thus, each experiment is designated not only by a number, but by a letter indicating whether it is intended for the student or the instructor.

The scope of these experiments, which make up the bulk of the book, is quite extensive. In fact, to this writer, the chief question which arises in evaluating the authors' accomplishment is whether or not the attempted coverage in subject matter is, if anything, too wide, leading to the impression of a certain degree of superficiality which detracts from the obvious merits which the book otherwise exhibits.

The list of experiments includes the following: inorganic chemistry, further classified under the headings of nonmetals and metals (also including a selection of quantitative analytical operations); organic chemistry, subdivided into aliphatic and aro-

matic compounds (including a brief reference to qualitative and quantitative organic analysis), foodstuffs and a few biological substances; and physical chemistry, including properties of gases and of solutions, thermochemistry, electrochemistry, colloids, chromatography, spectroscopy, luminescence, and radioactivity. Nine pages of tables of useful constants, followed by a detailed index, complete the volume. The typography and the quality of the paper used are both very satisfactory.

There can be little doubt that this work will prove to be of service in aiding the student to acquire facility in the various experimental chemical techniques in which he may become engaged in the course of his training; and that likewise the instructor will find herein many useful ideas to assist him in preparing his experimental lecture demonstrations.

WALTER C. SCHUMB

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● COAL: ITS FORMATION AND COMPOSITION

Wilfrid Francis, **Consulting Chemist and Fuel Technologist. St. Martin's Press, Inc., New York, 1954. viii + 567 pp. 200 figs. 138 tables. 16 × 24 cm. $17.50.**

THIS volume represents a new summary of the research work carried out on the formation and constitution of coal, in conformity with the pattern laid down in the "Monograph on the Constitution of Coal," by M. C. Stopes and R. V. Wheeler (1918). The author is well qualified for this task since he was one of Wheeler's first students, and also worked with Reinhardt Thiessen of the U. S. Bureau of Mines, who was preeminent in this field.

In discussing the individual subjects considered, the author has been selective in his choice of references and has not attempted to include a complete synthesis of all published papers. It is unusual in a volume of this sort to include so much original data not previously published; this enhances the value of the book to all interested in this subject. Many of the excellently reproduced photomicrographs, showing the microstructure of plants, peats, and coals, were provided by the original workers. The tables contain much valuable information, some of which has not been previously published or which has appeared only in reports not readily available.

After a brief review of the mode of accumulation of coal-forming plant debris in the first chapter, a detailed description is given of the structure of the coal-forming plants themselves. This is followed by a concise review of the chemistry of plant products to aid in an understanding of the chemical changes that must have occurred in the coalification process. The next two chapters discuss the formation and composition of peat and lignitous coals. Chapter 6 is entitled The Coal Series—Terminology, Structure and Petrology. The seventh and eighth chapters overlap somewhat in considering the classification and graphical-statistical studies of reaction processes and, in this reviewer's opinion, could be improved with better integration of published papers with the author's own development of a "rational classification." Interesting and competent discussions are given on normal and abnormal coal-forming processes and on the inorganic constituents of coal in the next two chapters. The final chapter considers several physical properties of coal, including structure as derived from heat of wetting and reflectance. While many of the subjects discussed are still controversial, the author does not indulge in polemics, but instead very ably presents consistently his own interpretations. Besides the usual author and subject indexes, the volume includes an appendix of twelve pages describing research procedures for the detailed examination of coals and coal-forming products.

The book is excellently produced, and the relatively high cost may be attributed in part to the large number of illustrations.

H. H. LOWRY

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● DIELECTRICS AND WAVES

Arthur R. von Hippel, **Professor of Electrophysics and Director of the Laboratory for Insulation Research, Massachusetts Institute of Technology. John Wiley & Sons, Inc., New York, 1954. xii + 284 pp. Many figs. and tables. 22.5 × 28.5 cm. $16.**

THE author begins by extending the conventional definition of dielectrics to the broad field of nonmetals in general, with metals as a limiting boundary case, and then proceeds to explore the experimental and theoretical consequences of the following hypothetical assembly: "We may pretend that a dielectric can be exposed to electric or magnetic fields of any frequency by filling a capacitor or a coil with the material in question and connecting it to a voltage source ranging in frequency from zero (direct current) to X-rays ($\approx 10^{18}$ c.p.s.)." His goal is to present to the reader the domain of science in which the interests in the above experiment of the physicist, the chemist, and the electrical engineer overlap. This is a formidable task, but despite the author's mildly pessimistic foreboding in the preface, this reviewer feels that the mission has been accomplished.

The book is divided into two main sections; in the first, the macroscopic properties of dielectrics are considered, while in the second, a correlation of these with molecular models is the objective. The physicist necessarily has the dominant role in both parts, because his vocabulary is comprehensible to both engineer and chemist; as might be expected, circuit and field theory are the guiding principles in the first section, while classical and quantum statistics take over in the second. Alternatively, the first approach might be described as continuum theory, while in the second, the discrete structure of matter and radiation is the center of attention.

The scope of the work is by definition far beyond that of previous books on dielectrics; in addition to dielectric constant, loss factor, and dipole moments, we find microwave spectroscopy, piezoelectricity, ferroelectricity, magnetic properties, and semiconductors among the new subjects presented. It becomes clear to the reader that the earlier limitations of the subject were artificial and unnecessarily restrictive to thinking. If we want to understand the fundamental structure of matter, it becomes necessary to consider all kinds of interaction between ultimate particles and electromagnetic energy. This thesis is developed in a masterly fashion by the author. Free use of mathematical methods is made, and a competent knowledge of theoretical physics is assumed; the book is not intended for beginners. There are a few curious pedagogical anomalies in the text. For example, complex numbers and transformations of coordinates are explained in elementary detail, while familiarity with many more sophisticated concepts is taken for granted. Some of the expository sections, such as those on wave mechanics and resonance theory, are so compact that they serve primarily to remind the reader that he should review these subjects in order to understand what follows. Fortunately, the bibliography contains an excellent compilation of more voluminous treatments of the many special topics which the author has included in his survey. Another useful and fascinating item in the bibliography is the citation of original fundamental sources. Papers of Poisson, Laplace, Gauss, Wien, Maxwell, Stokes, and Kirchoff represent a random sample.

No scientific library can afford to be without this book, because it should be available for study and reference to all three groups to whom the author has addressed it. The price, however, places it beyond the means of the graduate student.

● DIELECTRIC MATERIALS AND APPLICATIONS

Edited by *Arthur R. von Hippel,* Professor of Electrophysics and Director of the Laboratory for Insulation Research, Massachusetts Institute of Technology. Published jointly by the Technology Press of M. I. T. and John Wiley & Sons, Inc., New York, 1954. xii + 438 pp. Many figs. and tables. 22.5 × 28.5 cm. $17.50.

THIS book is intended as a companion volume to von Hippel's "Dielectrics and Waves." It is a carefully edited compilation

of the lectures and discussions held at the Laboratory for Insulation Research at the Massachusetts Institute of Technology in September, 1952. In all, 22 writers collaborated. They include representatives from university, industrial, and federal laboratories. Both producers and consumers of dielectrics are included in the industrial panel. The session was deliberately planned to bring together the academic approach of "Why?" and the practical attitude of "How?" and "What's it good for?" By and large, the group succeeded; publication of this volume makes available to the technological and scientific public the essence of the symposium.

The collection opens with a 43-page summary of theory. In it, von Hippel covers the salient points of the companion volume and naturally plagiarizes himself freely. The second section covers experimental methods of measuring properties of nonmetals; it includes bridge, resonance, and wave-guide techniques for determining complex permittivity. Measuring instruments and methods of using them are described in practical detail. Next, brief reviews of ferromagnetic measurements, microwave spectroscopy, and magnetic resonance are presented. The third section deals with applications. Gases, liquids, plastics, and ceramics are first discussed as classes of materials. Then applications of these materials as insulators in capacitors, cable, and other equipment are reviewed. The treatment ranges all the way from purely empirical to abstract theoretical, and suggests that there was a free exchange of ideas between the two schools at the symposium. "The last word in this discussion is properly left to a cable engineer who knows from bitter experience that not the office and laboratory, but deserts and sewers are the final proving ground for his product." Next, dielectrics as rectifiers, transducers, amplifiers, and memory devices are summarized. The discussion closes with statements by representatives of the Air Force, the Army, and the Navy concerning the reasons underlying some of the specifications for dielectrics which have been set up by the armed services. The last section of the book is a photographic reproduction of the "Tables of Dielectric Materials," which contain electrical properties of about 600 materials measured (for the most part over a wide range of frequency and temperature) at the Laboratory for Insulation Research. Practically all the materials are industrial compositions rather than chemically defined compounds, and as such represent properties of individual samples.

This book is recommended for the libraries of industrial research laboratories and technological schools. The academic man will find many things in it to stimulate his curiosity, and it may serve to increase his respect for the practical man who must obtain a solution for his problem, regardless of whether or not there exists a theoretical basis of approach. As in many other fields, art is still ahead of science in practical dielectrics.

RAYMOND M. FUOSS

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● THE PROPERTIES OF GLASS

George W. Morey, Geophysical Laboratory, Carnegie Institution of Washington, D. C. Second edition. A. C. S. Monograph No. 124. Reinhold Publishing Corporation, New York, 1954. 591 pp. 157 figs. 192 tables. 16 × 23.5 cm. $16.50.

THE first edition of this work, which appeared in 1938 as No. 7 of the A. C. S. Monograph Series, quickly won recognition as an authoritative reference and guide to research.

In his preface to the new edition, the author states, "I have tried to include...all new measurements on glasses of known composition, with especial emphasis on systematic studies. In addition, much new material has been included on complex and commercial glasses, on theoretical speculations, as well as new sections on the effect of heat treatment on the properties of glass, and of absorbed radiation." The original chapter headings have been retained in the revision: I, History and Definition; II, Devitrification; III, Composition; IV, Chemical Durability; V, Viscosity; VI, Annealing; VII, Surface Tension; VIII, Heat Capacity; IX, Thermal Conductivity; X, Density; XI, Coefficient of Expansion; XII, Elastic Properties; XIII, Strength; XIV, Thermal Endurance; XV, Hardness; XVI, Optical Properties; XVII, Electrical Conductivity; XVIII, Dielectric Properties; XIX, Magnetic Properties; XX, Constitution. The general index of the first edition has been replaced by separate subject and author indexes. In addition, there is a special index which refers to the properties of glasses by systems of two, three, four, and five components.

Those familiar with the first edition will find much of it incorporated, unchanged, in the new edition. Entire paragraphs—sometimes whole sections—have slipped by unchallenged. For example, the following statements appear in the new edition exactly as they did in the first edition, 16 years and one world war earlier (italics are used by the reviewer for emphasis):

"Much of this increase in knowledge was the direct product of the enforced extension of the optical glass industry during *the War*" (page 19). "...one of the important *post-war* developments in America" (page 78). "Some *recent* publications on the coefficient of expansion of glass,..." (page 270). (The latest date is 1934.)

In the first edition the author quoted three dictionary definitions of glass ("The Century," 1914; the "New Standard," 1932, and "Webster's New International," 1935). These three quotations and the references appear, unchanged, in the new edition (page 23). Recent revisions of these same works, as well as foreign dictionaries, were ignored.

A table from the first edition (Table I-3), showing world-wide glass production in the mid-thirties, appears, unchanged, in the new edition (Table I-3). The author explains that: "Present world conditions are such that it is not possible to bring it up to date." But the reader will probably feel that he deserves, at this point, such fragmentary data as are available.

In spite of such inadequacies in the revision, Dr. Morey has produced, in both the original and the revised editions, an excellent auxiliary textbook of physical chemistry. He meticulously introduces each topic with a consideration of the principles involved and definitions of the terms and units employed. His "text" is most notable for its treatment of heterogeneous equilibria and for its comprehensive phase diagrams.

ROSS A. BAKER

SAN DIEGO, CALIFORNIA

● PHYSICAL CHEMISTRY

A. J. Rutgers, University of Ghent, Belgium. Interscience Publishers, Inc., New York, 1954. xviii + 804 pp. Many figs. and tables. 16 × 23.5 cm. $8.50.

THIS new book, an English translation of the original Dutch edition, points up very clearly the wide difference in scientific background imparted to the European student as contrasted with the American. In addition to the usual topics presented in almost all physical chemistry texts, such as properties of gases, classical and statistical thermodynamics, equilibria, ionic and nonionic solutions, kinetics, and atomic and molecular structure, Rutgers includes fundamental theoretical topics such as the Maxwellian field equations, classical theoretical mechanics, and wave mechanics, as well as a chapter by Alfrey on the physical chemistry of high polymers. The truly distinctive character of this book lies in its viewpoint, so very different from American texts in its method of presentation. First, as emphasized by Debye in his foreword, new subjects are introduced with a historical perspective, that is, they are described in the way they were originally conceived and subsequently developed. Thus, the student becomes aware of the actual character of research in conceptual fields, whereas a strictly logical deductive development may leave him more impressed on aesthetic grounds but utterly confused as to how the basic principles were conjured

up in the first place. Second, each subject is developed rigorously and fully, rather than in a sketchy introductory manner on the assumption that subsequent courses will go over the same ground in a rigorous fashion.

This book is eminently suited in this country for graduate students in chemistry. On the other hand, because of differences in our methods of organization of courses as well as our philosophy of presentation, Rutgers would not be suitable as a text for the usual undergraduate course in physical chemistry. There is the minor inconvenience that problems are not present for student drill, although occasional numerical examples are worked out in the discussion, particularly in connection with thermodynamic computations. This difficulty could be overcome readily by combining this text with a problem book such as Sillen, Lange, and Gabrielson, or Noyes and Sherrill. On the other hand, it would not be feasible under normal current arrangements to cover a major fraction of Rutgers in a typical one-year undergraduate course; and certain parts of it require a background in physics far beyond that of the normal entrant to a first course in physical chemistry.

With but little reflection, it becomes apparent that the Rutgers approach is more economical with the student's time in the long run. Furthermore, students completing our usual undergraduate course can hardly be expected to do more than recognize the language when they encounter it; one feels confident that a student who has successfully mastered Rutgers' book would be articulate in the language of theoretical chemistry.

I. M. KLOTZ

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● TEXTILE FIBERS

J. Merritt Matthews. **Edited by *Herbert R. Mauersberger,* Director, Textile Department, Fairleigh Dickinson College. Sixth edition. John Wiley & Sons, Inc., New York, 1954. x + 1283 pp. Illustrated. 15 × 23 cm. $16.50.**

EVERYONE who has worked in the field of textile chemistry has heard of "Matthews," and most have used the book sometime in the years since 1904 when the first edition was published. Although many works have appeared since that first edition, Matthews' "Textile Fibers" has held a leading place as an authoritative source of information on all aspects of the fibers used by the textile industry.

As the industry advanced the book was repeatedly revised. This sixth edition brings the work up to date on the newer synthetic fibers.

The first four editions were the work of Dr. Matthews himself; the fifth and sixth have been compiled by a staff of contributors, under the editorship of H. R. Mauersberger.

The first chapter gives a very broad survey of the entire field of fiber science, covering much the same material as the first two chapters of the fifth edition. This is followed by a comprehensive chapter on the chemistry of cellulose. Further along there is an adequate chapter on the chemistry of wool. The coverage of the chemistry of the synthetic, high-polymer fibers is, however, very brief.

The book contains many excellent photomicrographs of fibers, those of cotton being especially noteworthy.

The important subject of fiber identification, analysis, and testing is well covered in a chapter by Professor E. R. Schwarz, of M. I. T.

The volume has grown from a textbook, which it was when Matthews first wrote it, to a reference source. The very extensive coverage of chemical, physical, commerical, and manufacturing data, with references to original sources, makes this book an invaluable fount of information on any textile fiber.

When this reviewer entered the textile field, it was: "Look it up in Matthews," because Matthews was the only source of information on fibers; today it is: "Look it up in Matthews," because it is the most convenient and comprehensive reference work in a now very extensive field.

WILLIAM G. CHACE

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● SYNTHETIC RUBBER

Edited by *G. S. Whitby, C. C. Davis,* and *R. F. Dunbrook.* John Wiley & Sons, Inc., New York, 1954. xi + 1044 pp. Figs. and tables. 16 × 24 cm. $18.

AN ENORMOUS amount of recently acquired knowledge was organized and classified to produce this book, which will be a standard source book for many years to come. The gratitude of the rubber industry is owed to the editorial board for a well designed volume, and to the many contributors for coherent, readable chapters on their individual specialties. The appearance of this treatise now is especially timely as the prospect arises of the American synthetic rubber industry's coming entirely under the direction of private ownership within the near future.

This volume is divided into 26 chapters, a name index, and a subject index. Each chapter is followed by its bibliography of from 50 to 300 references. The name index is complete, in that it includes authors both as they appear in the text and in the bibliographical references.

Professor Whitby's introduction makes plain the extent of postwar usage of synthetic rubber in the United States. For instance, in the third quarter of 1951, 64 per cent of the United States' rubber consumption was synthetic, five-sixths of this percentage being GR-S types and one-sixth being the specialty rubbers, Butyl, Neoprene, nitrile rubber, etc. The editor-in-chief illuminates several topics, incidentally pointing out the road for further advances, such as improvement of heat transfer in polymerization reactions, improved homogeneity of polymers, elucidation of the nature of reinforcement, and further development of specialty polymers. In conclusion he commends the enlightened direction of the government research program on synthetic rubber.

After a brief historical review (Chapter 2), five chapters cover the preparation of materials, summarizing the manufacture of dienes from petroleum, butadiene from alcohol, other methods of diene preparation, the manufacture of styrene, and the manufacture of GR-S. The next three chapters outline the fundamental knowledge on formation, makeup, and properties of elastomers under the headings of emulsion polymerization, chemical study of structure, and the physical chemistry of polymers and copolymers. Chapters 11 through 16 describe the industrial application of the GR-S type of synthetic, namely, processing and compounding of GR-S, testing methods, aging properties of GR-S, general compounding on GR-S, and, more generally, the application of synthetics to wire and cables, and synthetic hard rubber. Four chapters explain more or less unrelated fields, the reclaiming of synthetic rubber (which is really a problem in reclaiming mixtures of natural and synthetic), synthetic rubber resins, the expanding field of GR-S latex, and latex masterbatching. Other types of rubber take up the five ensuing chapters, one summarizing the explorations on diene polymers and copolymers other than GR-S, and one each discussing Neoprene, nitrile rubber, Butyl, and miscellaneous synthetics. The final chapter on German developments covers the polymer types made abroad, the German work on redox polymerization, and the methods of testing their rubbers.

There is much material on natural rubber scattered throughout the volume, because *Hevea* is the blank on so many measurements of elastomer properties. A comparison of this work with "The Chemistry and Technology of Rubber," the Davis and Blake monograph of 1937 to which many of the same authors contributed, will show how far scientific knowledge of elastomers has progressed in the ensuing years.

Since Butyl is simpler structurally than the other important

synthetics, it is not surprising to find more fundamental work reported on curing and reversion in connection with Butyl than with the others. Also, the benefits of catalyzed heat treatment of carbon-black masterbatches are discussed only in connection with Butyl.

Organic reinforcement is lightly discussed in two chapters, by styrene resins in Chapter 18 and by cumar resins, etc., in Chapter 15 in connection with wire and cable compounding. Tough combinations of resin and rubbers are passed over quickly, probably because little has been published on this subject.

The format and printing of the volume are good. None of the few typographical errors noticed distorted the intended meaning.

This book is highly recommended to anyone working in the field of rubber technology or polymer chemistry.

HOMER P. SMITH

LITTLE FALLS, NEW JERSEY

● ELEMENTS OF STATISTICS

H. C. Fryer, Agricultural Experiment Station, Kansas State College. John Wiley & Sons, Inc., New York, 1954. viii + 262 pp. Figs. and tables. 15.5 × 23.5 cm. $4.75.

THIS text is intended for use in a first course in statistics with college algebra as a prerequisite. Although slanted strongly toward application rather than theory, the book uses illustrative material which is quite unspecialized, reflecting the author's belief that students interested in using statistics in different fields of application can be well served by a common introductory course.

For the most part the subject matter centers about single-variable distributions, principally the binomial and normal. The concepts of sampling distributions, confidence limits, and testing of hypotheses are emphasized in a fully modern manner. The one concluding chapter on correlation does not use to a corresponding extent the idea of a joint two-variable distribution. The book contains a brief but interesting historical introduction.

The method of presentation consists very largely of concrete illustration. This may come close to overemphasis at some points; for example, although several applications of the chi-square test are worked through fully, one is not told that the test is suitable for comparing a sample with *any* hypothetical distribution. On the whole, however, the combination of an ample explanatory text with an abundance of problems and very adequate tables, promises a wide usefulness for the book.

P. RUDNICK

SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

● SOILS

G. V. Jacks, Commonwealth Bureau of Soil Science, Rothamsted. The Philosophical Library, New York, 1954. ix + 221 pp. Figs. and tables. 14 × 20.5 cm. $5.

IN DIRECTING himself to the farmer and student of agriculture Professor Jacks has done an outstanding job of treating technical subjects in an interesting, easily read manner. The general theme of soil management is developed in each chapter—a subject which Professor Jacks is well qualified to discuss.

Chapter 10 presents a unique treatment of plants and men as soil-farming factors, and in the History of British Soils, management is again emphasized in an interesting manner. The text should find wide acceptance by the audience for which it was written.

O. R. LUNT

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● THE OPTICAL PROPERTIES OF ORGANIC COMPOUNDS

Alexander N. Winchell, Emeritus Professor of Mineralogy, University of Wisconsin. Second edition. Academic Press, Inc., New York, 1954. xviii + 487 pp. 153 figs. 15.5 × 23.5 cm. $12.

THIS book collects in one volume the recorded optical properties of 2500 solid organic compounds, about 700 more than were listed in the first edition published in 1943. It covers the literature to October 1, 1952. The compounds are arranged according to the system of classification used in the fourth edition of Beilstein. This section of the book occupies 336 pages. It is followed by two determinative tables, the first of which lists the compounds in the order of increasing value of the highest measured refractive index and the second in the order of increasing value of the lowest measured refractive index. These tables, which occupy 57 pages, are followed by 43 pages of an index in the form of an alphabetical listing of the compounds, and 47 pages of a numerical and alphabetical key to two determinative diagrams which are enclosed in a pocket inside the rear cover of the book.

Despite the exhortations of converts to the use of the microscope in chemical investigations, most chemists shy away from this approach to the solution of their problems. Even when they venture to make use of the microscope, they are inclined to use it to observe gross characteristics, to determine melting points on a hot stage, or to carry out and observe chemical reactions or crystallization of a melt on a slide. Rarely does a chemist make use of the optical and crystallographic properties in the characterization of organic compounds.

Several reasons may account for this disinterest. Undoubtedly the chief reason is that the microscope is an unfamiliar tool. Unlike Pasteur, most chemists have not studied crystallography as part of their basic training, and the terms used by crystallographers are foreign to them. For example, the data for chloral hydrate given by Winchell on p. 12 is as follows:

"Chloral hydrate [$CH(OH)_2.CCl_3$] is monoclinic prismatic with $a:b:c: = 1.915:1:1.589$, $\beta = 120°7'$. Space group $P2/c$; a 11.57, b 6.04, c 9.60 Å. U. C. 4. Crystals plates with perfect 001 cleavage. D 1.90. M.P. 51.7°. The optic plane is 010; X, $c = -59°$. $(-)2V = 20°50'$. $N_X = 1.5393$, $N_Y = 1.5995$, $N_Z = 1.6017$, $N_Z - N_X = 0.0634$ Na. Ref: 117, 453."

One glance at it and the uninitiated chemist will return to his test tubes. If he does look into the meaning of the symbols, the processes involved in determining Miller indexes and refractive indexes seem tedious to him. He would much rather establish identity by preparing an authentic sample and determining the melting point of a mixture with the material in question and even make a derivative or two and determine their melting points. Although this process may be more time consuming than making a number of observations under the microscope, he *likes* to carry out reactions, or he would not be a chemist.

Winchell tries to reduce the number of observations that must be made and render the data more readily usable by providing the determinative tables and charts by means of which the identification of a compound may be made from the refringence, birefringence, and optic sign, or from the refringence, birefringence, and optic angle. However, these properties can be used only to limit the possibilities. For example, the statement on p. 442 that "if the constant index is 1.615 and the other index is 1.830, the sign is positive, the birefringence is 0.215, and plate I shows that the substance is number 191, which the key shows to be benzoselenazole guandidine sulfate" very possibly is not true. These data merely identify the compound among the 1800 compounds on Plate I and not among the hundreds of thousands of other solid organic compounds.

This comment leads to yet another reason why optical properties of organic compounds have found so little use. They apply only to solids, and they have been recorded for only a small fraction of the known solids. The accumulation of data on 2500 compounds may sound impressive, but many of these compounds are

rarely encountered, and many others merely are different salts of the same compound. Thus, the 46 acyclic hydroxy compounds represent only 23 different alcohols, and 14 are salts of ethyl hydrogen sulfate. Of the 99 compounds listed under "Monocarboxylic Acids and Derivatives," formic acid and acetic acid account for 52, and propionic, butyric, valeric, palmitic, and stearic acids for 38. All but 27 are salts from inorganic bases. Of the 40 compounds listed under "Isocyclic Dicarboxylic Acids and Derivatives," 13 are salts of phthalic acid, 9 are acid esters of 3-nitrophthalic acid, and 10 are *N*-alkyl derivatives of 4-nitrophthalimide. Again there are 40 derivatives of quinine listed, mostly salts, of which 17 are salts of inorganic acids and only 21 might be of use for the identification of compounds other than quinine. The fault here, of course, lies with the organic chemists who have not determined the optical properties of new compounds, but this lack of information does limit the usefulness of the method at the present time.

Certainly the appearance of the second edition of Winchell's collection of published data on the optical properties of organic solids should be an incentive for organic chemists to make greater use of the polarizing microscope. At least it has caused this reviewer to renew a resolve, made many times previously, to learn how to determine the optical properties of crystals. Perhaps it will help others to do likewise to quote the following passage from p. 2 of Hartshorne and Stuart, "Crystals and the Polarizing Microscope": ". . .the knowledge necessary to apply it [the polarizing microscope] to simple problems can be acquired by the beginner in a comparatively short time. The ability to make the fullest use of the method will, it is true, come only with experience, but this may be gained gradually and without undue interruption of ordinary work. It is thus entirely feasible for any chemist to learn and practice this method without becoming a crystallographic specialist."

CARL R. NOLLER

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● GUIDE FOR SAFETY IN THE CHEMICAL LABORATORY

The General Safety Committee of the Manufacturing Chemists' Association. **D. Van Nostrand Co., Inc., New York, 1954. xxiii + 234 pp. 39 figs. 14 × 22 cm. $4.25.**

DURING recent years there has been increasing recognition of the responsibility of the chemical industry in the safe manufacturing, handling, and use of its products. Providing mechanical safety guards and protective equipment cannot be effective unless the worker has been educated to use the facilities properly and a responsible safety attitude has been developed. Accepting the maxim that any chemical can be handled safely if proper precautions are observed, the Manufacturing Chemists' Association through its General Safety Committee prepared this "Guide for Safety in the Chemical Laboratory." Their aim is the promotion of higher standards of safety by stressing safety during earliest training in technical institutions, colleges, and universities. The manual is intended to serve as a guide to subject matter which can be used by instructors in lectures to inculcate in students an appreciation of the importance of the role of safety in chemistry.

The scope of the book is very broad, covering general rules for laboratory safety, laboratory design and equipment, handling glassware, storage, flammability and explosion hazards, chemical and toxicity hazards, radiation hazards, pressure vessels, protective equipment, first aid, and packaging and transportation of chemicals.

The chapter Laboratory Design and Equipment stresses the use of fire-resistant and noncumbustible construction and general layout with particular emphasis on exits. Adequate ventilation, illumination, storage and disposal facilities, and good housekeeping are other essential factors. The chapter Flammability constitutes almost one-fourth of the book and consists mainly of the flash point, ignition temperature, and explosive limits of a list of chemicals, with 135 references. The space devoted to this section is unduly long in relation to the other material covered. This seems particularly true when one considers the broad scope of the book and small amount of space devoted to chemical hazards, toxicity, and radiation.

As might be expected in a book prepared by a number of persons, there is repetition of material in several sections, and much has been omitted that might well have been included. Lack of references to numerous well known books and other sources of information is a particular weakness in view of the fact that the book has been prepared for use in colleges and universities.

Nevertheless, the book is a worth-while contribution to chemical safety and should be valuable and useful in encouraging early training in safety. The subject matter covered serves as a good outline of the numerous aspects of safety and provides a good starting point for futher contributions of this type. Anyone engaged in handling chemicals should find the book profitable reading.

H. H. SCHRENK

INDUSTRIAL HYGIENE FOUNDATION OF AMERICA, INC.
PITTSBURGH, PENNSYLVANIA

● THE THEORY OF THE PHOTOGRAPHIC PROCESS

Edited by *C. E. Kenneth Mees,* Vice-President in Charge of Research, Eastman Kodak Company. Revised edition. Macmillan Co., New York, 1954. x + 1133 pp. 416 figs. 60 tables. 15 × 23 cm. $21.50.

THIS book is written in collaboration with the editor's colleagues in the Kodak Research Laboratories. Its stated purpose is to provide a general handbook of the subject of the photographic process as a guide to the literature and as a summary of its conclusions. It is the reviewer's opinion that the authors have achieved these goals and have produced a book which is unequaled in its field. The subject matter is divided into five sections: The Photographic Material; The Action of Radiation; Optical Sensitizing; Development and the After-Processes; The Physics of the Photographic Process. References to the original literature follow each of the 25 chapters. The entire content of the first edition has been rewritten. New chapters have been added on The Action of Charged Particles on the Photographic Emulsion, The Latent Image Produced by X Rays, and The Sensitometry of Color Films and Papers.

The review and evaluation of the extensive published work are given in exhautive detail at times, but in general the authors have summarized well the important developments concerning the various aspects of this very complex research field. The large number of excellent graphs, drawings, photographs, and tables illustrates the material well and helps to maintain the interest of the reader. Discussions of emulsion-making are not included; the author has stated that his knowledge of this subject was acquired in confidence, and he is not entitled to publish the material with the frankness which alone would justify any publication. The reader may be somewhat disappointed at the relatively small coverage afforded the various color photographic processes. However, the treatment may be as extensive as is justified by the proportion of the total photographic literature which deals with the color processes.

It is likely that the usefulness of the volume will be restricted primarily to the scientists and teachers interested in photographic theory and research, although others in the scientific fields should find that many of the sections provide stimulating reading. It will be especially gratifying to the scientist who is uninformed in the details of the photographic process to see the extent to which our knowledge of this extremely complex field has been extended through the multitude of diverse research studies.

JACK G. CALVERT

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JOURNAL OF CHEMICAL EDUCATION

ANNUAL *Spring* BOOK LIST

To supplement our complete book list which appears each year in the September issue (in connection with the Chemical Education Book Exhibit) we present a list of new and forthcoming titles. This new feature is the direct result of requests made by our readers for an advance list to aid them in the selection of books for classroom, laboratory and reference use.

The list which follows is roughly classified using categories similar to those in our annual book exhibit list. In most instances the publication date, the number of pages and price are approximate. More information about any of these titles, or, in some cases, examination copies, may be had by writing to the particular publisher. Names and addresses appear at the end of this bibliography.

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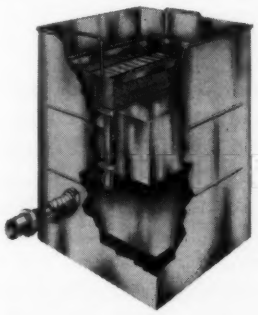

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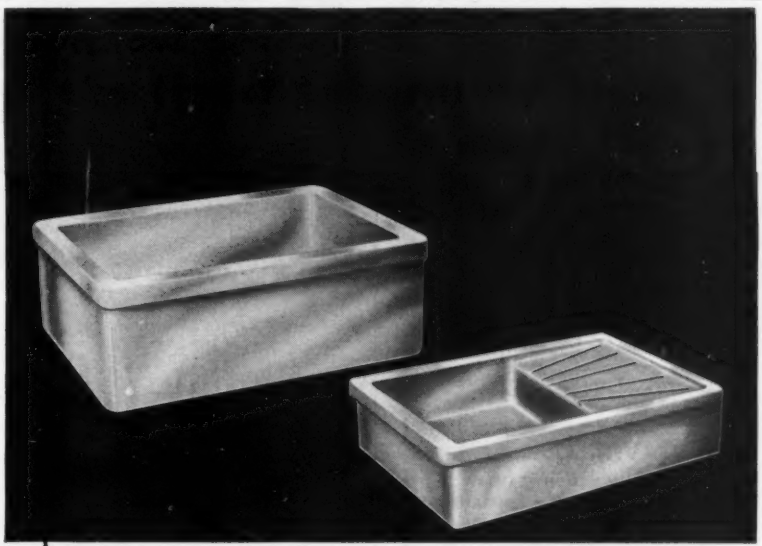

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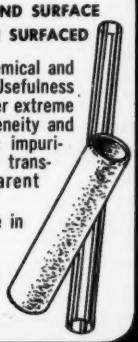

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For perchloric acid fume hoods.

Alberene Stone has a low absorbency factor of 0.15%. It's essentially nonstaining. Easily cleaned. And readily machined for tongue and groove, watertight construction.

Both of these features are absolutely essential for perchloric hoods — where thorough water flushing and removal is necessary to keep them deposit-free.

Further, with Alberene Stone — *the natural silicate stone whose surface goes all the way thru* — the all-silicate mineral components resist chemical attack.

Our engineers are ready to help you select or design perchloric hoods or other special-purpose hoods. Alberene Stone Corporation, 419 Fourth Avenue, New York 16, N. Y.

ALBERENE STONE

provides LOW ABSORBENCY protection

23, Ohio. Micro-volume analysis possible with the syringe microburet is said to reduce by a factor of 100 the amount of fluid commonly required in macro procedures.

Automatic Temperature Controller

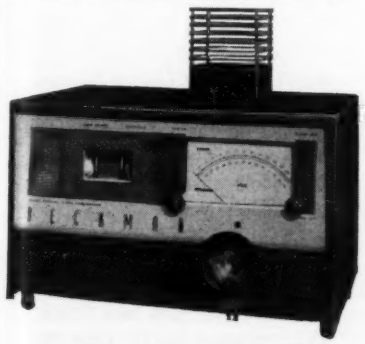
The Amplitrol is a new and different instrument, designed to give accurate and fully automatic control of temperature in electric furnaces, ovens, and other industrial heating devices. While utilizing the established principle of the potentiometer, there is no necessity to standardize the instrument, either manually or automatically, at any time. Instruments are available in a wide selection of scale ranges, with either Fahrenheit or Centigrade dials and for base-metals thermocouples of Iron versus Constantan and Chromel versus Alumel. Complete information is available by writing direct to the manufacturer, Thermo Electric Manufacturing Co., 471 Huff Street, Dubuque, Iowa.

Low Cost Microscope

Hard-pressed school budgets will welcome the new low-cost No. 73 Microscope, designed for student use by the American Optical Company, Instrument Division, Buffalo 15, New York. The single combination coarse and fine adjustment control simplifies operation, and will hold real appeal for the budding scientist whose primary concern is specimen study via the microscope, rather than a detailed study of the instrument itself.

New Direct Reading Flame Photometer

A faster, simpler instrument for flame analysis of sodium and potassium has just been announced by Beckman Instruments, Inc. This compact Flame Photometer features simplified operation and an easy-to-read meter calibrated directly in milliequivalents of sodium and potassium—no reference to calibration curves or conversion tables is necessary.



A pilot light and preset adjustments give instantaneous and efficient flame operation. Moving the sodium or potassium lever into position automatically places the proper filter between the flame and the phototube and brings the correct calibration pots into operating position. Technicians without previous experience can soon handle 50 to 60 determinations per hour.

Detection range, as indicated on the meter, is 0 to 2.8 meg/l for sodium and 0 to 0.14 meg/l for potassium. Utilities required for operation are natural gas or propane, compressed air and 115 volt 50/60 cycle ac. For further information request bulletin 396 from Beckman Division, Beckman Instruments, Inc., Fullerton 1, California.

Powder Pistol

The need for a simple process to produce a film or coating to facilitate evaluation of new materials or processes, was the inspiration for the Schori Process Flame Spray Powder Pistol. The Model L Pistol will spray any powdered metal or thermoplastic resin or combination of the two. As little as 50 grams of powder will produce a coating that can be subjected to test.

The Schori Process is being used extensively for laying down films of new materials developed in the laboratories subsidized by the Atomic Energy Commission.

Complete details are available from Schori Process Division, Ferro-Co Corporation, 8–11 Forty-third Road, Long Island City 1, New York.

High-Purity Thioacetamide

The J. T. Baker Chemical Company announces the availability of Thioacetamide, CH_3CSNH_2, in a reagent grade of high assay and controlled purity. On hydrolysis, it provides a convenient source of sulfide ion for both the quantitative and qualitative separation of the ions of heavy metals. The use of Thioacetamide bypasses the many disadvantages of hydrogen sulfide, such as toxicity and nauseating odor. The use of Thioacetamide does not

Planning the most efficient, convenient and economical installation of laboratory equipment—to fit your specific needs—is a specialist's job. That's why it's so important to consult Kewaunee during the planning stage.

Start with the man who knows – the Kewaunee Laboratory Engineer. Available to you without cost or obligation, he'll show you how to achieve work-saving convenience and time-saving efficiency... how to save money . . . how to plan for future expansion . . . how to avoid future regrets. And he'll explain the Kewaunee Unit Assembly Plan, which permits the installation of the very finest laboratory equipment—in wood or metal—at modest cost.

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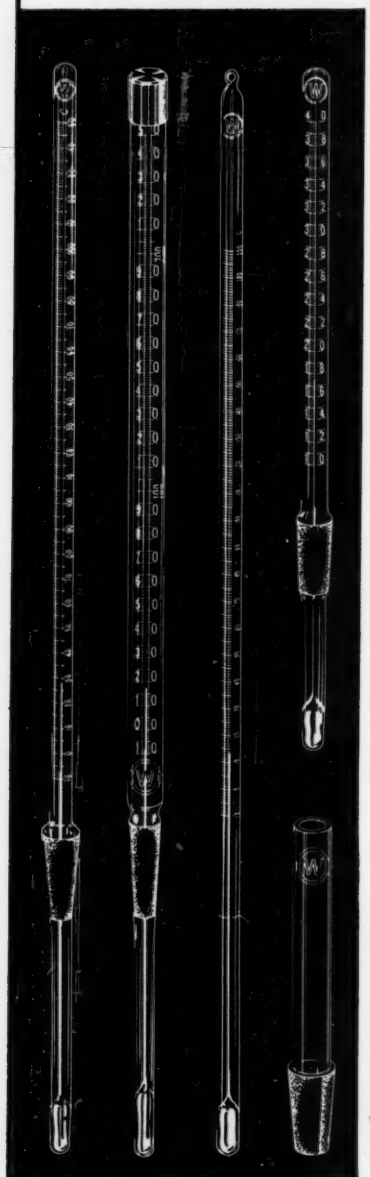
WILMAD THERMOMETERS



When Wilmad precision teams up with the prices you ordinarily pay for inferior thermometers . . . that's news!

Study the prices listed in the tables below and order enough for your lab today.

ENGRAVED STEM THERMOMETERS— 10/30 PRECISION GROUND JOINT — WHITE OR YELLOW BACK GLASS

(SEE FIG. 1)

STEM	110C	150C	250C	360C
3"	$3.35	$3.95	$4.35	$4.60
4"	3.55	4.15	4.50	4.75
5"	3.60	4.20	4.60	4.85
6"	3.80	4.55	4.85	5.10
7½"	4.05	4.80	5.10	5.35
8½"	4.10	4.85	5.30	5.55
10"	4.80	5.30	5.50	5.70
11"	5.00	5.50	5.70	6.00

ENCLOSED SCALE THERMOMETERS — PYREX BRAND GLASS — PRECISION GROUND — INTERCHANGEABLE 10/30 JOINT

(SEE FIG. 2)

STEM	150C	250C	360C
3"	$5.60	$5.95	$6.40
4"	5.90	6.20	6.65
5"	6.15	6.50	6.95
6"	6.45	6.75	7.20
7½"	6.70	7.05	7.50
8½"	7.00	7.30	7.75
10"	7.25	7.60	8.05
11"	7.80	8.15	8.60

ENGRAVED STEM THERMOMETERS — PRECISION GRADE — PRICES ON SPECIAL RANGES AND STEM LENGTHS AVAILABLE ON REQUEST

(SEE FIG. 3)

Range -10 to	Division	Length	Price
110C	1°	12"	$1.45
150C	1°	12"	1.60
200C	1°	12"	1.75
250C	1°	14"	2.00
300C	1°	14"	2.15
360C	1°	15"	2.45

PYCNOMETER THERMOMETER (YELLOW BACK)

(SEE FIG. 4)

The yellow back of this thermometer makes for more accurate reading. Available with scale from 0° to 40°C in 1/5° increments. Thermometers have ⅗ 10/18 joint. Prices on request.

PRECISION BORE ADJUSTABLE THERMOMETER ADAPTER

with 10/18 joint Price $2.50

(SEE FIG. 5)

These thermometers are representative of the Wilmad line. We can supply many other types.

Send for detailed information on precision bore tubing catalog today.

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WILMAD GLASS COMPANY, INC.

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NEWS from FILTERTOWN

Extremely versatile E&D #613 is equally at home in the laboratory and the industrial plant.

In the former, it is used for analysis of blood to determine sugar content, for hospital analysis tests and as indicator papers.

In the latter, it is used for filtration of such widely diversified products as fruit juices, colognes, drugs, medicinal oils, pharmaceuticals, salt solutions and bees wax.

The physical characteristics of grade #613 are: .006 inches thick, smooth surface, rapidity 60, wet strength 4.8.

We, however, are the very first to admit the likelihood that it does some jobs better than others. And by better, we think in terms of clarity of filtrate, rapidity and economy.

Thus, we continually stress the advisability of permitting our know-how to help you select the right grade of filter paper for your particular filtration process—or product.

Since E&D has sixty-five years of experience and research tucked away, and since E&D is the only company in America exclusively devoted to the manufacture of filter paper, there's a more than reasonable chance that we can be of help to you.

Write for free samples.

And ask for our Filtration Analysis Report if you have any doubts about whether you're using the right filter paper. No obligation, at all.

E&D The EATON-DIKEMAN Co. FILTERTOWN ® MT. HOLLY SPRINGS, PENNA.

require radically different procedures for the precipitation of sulfides. Sulfides precipitated by the use of Thioacetamide —unlike those with hydrogen sulfide—are coarsely crystalline, dense, easily filterable, and less contaminated by foreign ions. Thioacetamide, as offered by Baker, is a stable, crystalline product containing over 40% available sulfide.

Thioacetamide is finding wide application in industrial analytical laboratories for the quantitative separation of many metallic ions, and in college courses in qualitative analysis. An 8-page reprint of a review and article on the analytical use of Thioacetamide is available on request from the J. T. Baker Chemical Company, Phillipsburg, New Jersey.

NEW LITERATURE

● A new 28-page catalogue of radiation instruments has just been issued by NRD Instrument Company, 6429 Etzel Avenue, St. Louis 14, Missouri. The catalogue describes scintillation counters, scalers, and other circuits, as well as a variety of radioactivity counting accessories.

A copy is available on request.

● "Shriver Filter Presses—A Guide To Better Filtration" is a fine bulletin on the advantages, selection, operation, and mechanics of such equipment. Catalogue No. 55 is available from T. Shriver & Co., Inc., 810 Hamilton Street, Harrison, New Jersey.

● Cochrane Corporation, Philadelphia 31, Pennsylvania, designers and manufacturers of water conditioning equipment, offer a new, comprehensive 40-page book titled, "Handbook on Demineralizing," Publication 5800-B. This handbook compares various methods of water treatment, as well as indicating the comparison between demineralizers and evaporators. It goes into the characteristics of the various types of available cation and anion exchange materials and offers data on operating costs of demineralizing.

● A new issue of *Cenco News Chats*, No. 80, is announced by Central Scientific Company. The new issue features interesting items on electrical engineering including articles on the following: The American Institute of Electrical Engineers; Michael Pupin, late professor of electromechanics at Columbia University; and the importance of instrument selection in education and research.

A copy of this 24-page booklet *Cenco News Chats*, No. 80, may be obtained by writing to Central Scientific Company, 1700 Irving Park Road, Chicago, Illinois.

● An illustrated booklet describing the composition, manufacture, and application of Vycor brand 96 per cent silica glasses has been published by Technical Products Division, Corning Glass Works, Corning, New York.

Comparable with fused silica in properties and performance, Vycor brand glasses can be heated to 900 degrees Centigrade and plunged into ice water without breaking. In addition to extreme resistance to thermal shock, the glasses have exceptional chemical stability and high transmission of the ultraviolet and infrared bands of the spectrum.

Among the more common applications of Vycor brand glasses are stove top units

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with Stabilizing Watt-Type Governor

- REDUCES EXPLOSION HAZARD
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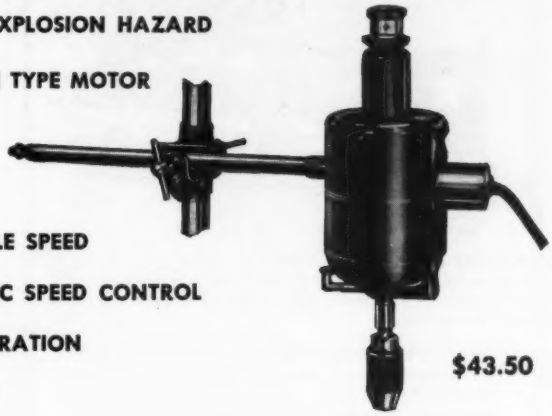

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No. 5230

5230. ELECTRIC STIRRER, Sparkless. Complete with 6-foot connecting cord, line switch, and plug. For operation on 50 or 60 cycles, 115 volts A.C. Each $43.50

5230A. ELECTRIC STIRRER, Sparkless, For 230 Volts, A.C. Consists of No. 5230 Stirrer equipped with a step-down transformer to permit operation on 230 volts 50 or 60 cycles A.C. Each $54.75

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SAVE with ENLEY... Get Your
Demineralized Water
(Without Regeneration)
at 2c—4c Per Gallon!

You can't beat the new Enley PERMA-DEMON for low initial cost and low per gallon cost. Improved manufacturing methods, reduced overhead and the radically new designed PERMA-DEMON all combine to bring you Demineralized Water at lower cost per gallon than can be obtained from any unit of comparable size.

The PERMA-DEMON is the only Water Demineralizer of its size that does not require Cartridge Replacement by the Manufacturer. It performs with the same economy as any larger Cartridge Type Demineralizer. Available now.

AT THE AMAZINGLY LOW COST OF ONLY $17.95 Complete

Comes packed with built-in carborundum porous stone filter and fiberglas screen.

SPECIAL FEATURE: The ion-exchange material can easily be removed and the PERMA-DEMON refilled with fresh material which can be obtained at the lowest net cost anywhere.

CHART BELOW EXPLAINING COST PER GALLON

mineral content parts per million (as $CaCO_3$)	output-Gallons per refill (1 pound of material)	cost per gallon per lb. of material—in cents
50	210	1.4c
100	102.5	2.75c
150	69	4.0c

based on material costing $3.25 per lb. and credit of 50c per lb. for exhausted material returned to Enley Products Inc. NET COST OF MATERIAL $2.75 per lb.

Other units available of larger resin capacity at comparable prices. Write for full details.

FULLY GUARANTEED
We Guarantee our products to perform as advertised or we refund your money.

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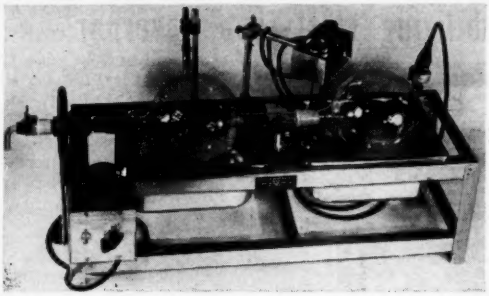
FLASH-EVAPORATOR



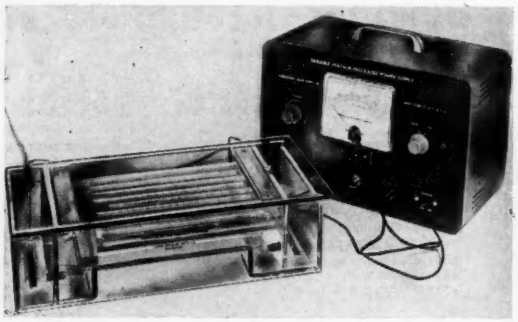
The FLASH-EVAPORATOR assures fast separation of heat and air sensitive solutions under vacuum, without foaming or bumping. The Flash-Evaporator is particularly helpful when using aqueous solutions and high boiling solvents.

Interchangeable evaporating flask from 100ml to 2000ml.
Easy deassembling of glass parts for cleaning or removal of concentrate.
Adjustable speed from 40 to 180 RPM.
Teflon and glass rotating joint eliminates lubrication.
Available for batch or continuous operation.

PRICE: MOD. FE-2 complete with Motor, 500 Watt Heater Evaporating and Condenser Flask, Stainless-steel Frame and Pans **$195.80**

Automatic Thermo-Regulator **$47.00**

PAPER or STARCH ELECTROPHORESIS OUTFIT (for less than $200.00)



Consisting of:

ELECTROPHORESIS-CHAMBER
made of clear Methacrylate plastic.
3 Different paper carriers, one of them water-circulated.
2 Platinum electrodes 4" long.
Leveling device between buffer chambers.
Plate glass cover

POWER-SUPPLY
500V 100Ma. Equipped with Polarity reversing switch.
Full wave rectification, 7 Tubes.
DC Voltage control from 0 to 500 Volts.

PRICE: Mod. EP-3C Complete outfit $198.00

PHOTOVOLT DENSITOMETERS
Models 425 and 525 available for use with above unit.

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Manufacturers of Scientific Instruments
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Filter Papers for Buchner Funnels

When using Buchner Funnels, workers are usually more interested in the precipitate than the filtrate hence WHATMAN Hardened Filter Papers from which the precipitate can be separated without tearing the paper or contamination with paper fibers are recommended.

Three grades of hardened papers are available:

No. 50—a very close textured paper, retaining fine precipitates but consequently rather slow filtering.

No. 52—medium rapid retaining crystalline precipitates.

No. 54—very open and rapid filtering for coarse or gelatinous precipitates.

All three grades are available in sizes to fit all standard size funnels from all dealers in laboratory supplies.

Would you like to know more about WHATMAN Filter Papers? A new catalog is yours for the asking.

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Remember that for chromatography and electrophoresis WHATMAN Filter Papers and Cellulose Powders are world renowned.

WHATMAN High Grade FILTER PAPERS

and heat lamp bulbs, calcining jars and trays, thermocouple protecting tubes, laboratory glassware, and germicidal lamps.

● The interesting possibilities that exist for the technological use of hydrogen peroxide vapor and means of vapor generation are described in new Bulletin No. 62, available from the Becco Chemical Division, Food Machinery and Chemical Corporation, Station B, Buffalo 7, New York.

Presented is a summary of information on hydrogen peroxide vapor illustrated by three tables and two graphs, as well as a bibliography on the subject.

● A chart which provides a quick, convenient means of translating any viscosity measurement into seven other standard units has just been released by the Nopco Chemical Company.

Methods of measuring viscosity vary from industry to industry and, even in the same field, from one company to another. This novel conversion nomograph has been designed to minimize the problems caused by the lack of standardization by providing a means of rapidly converting from one system to another.

The chart is available free of charge by writing to Dept. VC, Nopco Chemical Company, Harrison, New Jersey.

● A new edition of the manual, "Laboratory Glass Blowing with Pyrex Brand Glasses," has been published by Corning Glass Works.

The 20-page pamphlet offers laboratory personnel information about the working characteristics of Pyrex brand and Vycor brand glasses. Fundamental glass blowing operations and recommendation for suitable tools and equipment are included.

Copies may be obtained by addressing the Laboratory and Pharmaceutical Sales Department, Corning Glass Works, Corning, New York.

● A new recording gamma radiation monitor operated *entirely on dry cells* was recently announced by Jordan Manufacturing Co., Inc., 119 East Union Street, Pasadena 1, California. Ask for application data file 572.

MISCELLANY

★ The *University of Oklahoma Mathematics Letter* is a four-page publication of interest to high school and beginning college students and teachers. Copies will be sent without charge to persons requesting them and enclosing a stamped self addressed envelope plus a 3″ × 5″ card giving their name and school address. Send all requests to Professor Richard V. Andree, Department of Mathematics, The University of Oklahoma, Norman, Oklahoma. You owe it to your students to send for this interesting free publication.

★ Do you have a problem with hydrogen sulfide in your laboratory? Information is available from A. Daigger & Co., 159 W. Kinzie Street, Chicago 10, Illinois, on "Sulfi-Down" a specially stabilized thioacetamide which eliminates many of the conventional H_2S headaches.

★ "Your Career with the Instrument and Control Industry," is a college and university vocational guidance pamphlet recently published by the Recorder-Controller Section, Scientific Apparatus Mak-

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LABORATORY SHAKERS

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You control procedures from gentle to violent shaking and repeat any operation, exactly, at another time. Side clamps take various shapes and sizes. Top clamps take bottles and erlenmeyer flasks. Loads need not be balanced.

CAT. NO.	ITEM	PRICE
75-765	Build-Up Wrist-Action Shaker, Size BT for 8 top and 8 side flasks	200.00
75-750	Burrell Heavy-Duty Shaker, Size 40 for 40 flasks—flat-top only	345.00
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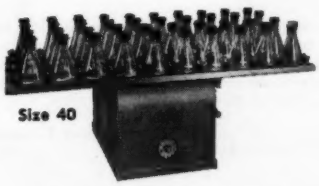
75-775	Build-Up Wrist-Action Shaker, Size BB for 8 side flasks	175.00

For 115 volts, 60 cycle, one phase. Other voltages to order.
For additional data, ask for Bulletin No. 307

ONE BASIC UNIT SERVES MANY DIFFERENT REQUIREMENTS

You Build-Up with the new 8-place flat-top and with side arms for 4, 12 or 16 flasks. One basic unit adapts to any combination.



HEAVY-DUTY MODELS

Extra powerful and rugged unit shakes up to forty erlenmeyer flasks or bottles. Available in flat-top design only.

Prices listed are F.O.B. Pittsburgh, Pa.

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ers Association. It tells the story of a "dynamic industry offering a fascinating challenge and opportunity to young engineers with vision, initiative, and resourcefulness."

Please address your request for copies to Mr. Hampton M. Auld, Executive Secretary, Recorder-Controller Section, Scientific Apparatus Makers Association, 522 Fifth Avenue, New York 36, New York.

★ How once wasted smoke from coke ovens is now converted into a wealth of basic chemicals used in the manufacture of aspirin, paints, fertilizers, wood preservatives, plastics, nylon, sulpha drugs, and countless other articles is the subject of a dramatic motion picture, "Waiting Harvest," just released.

It can be booked on a free loan basis by writing to the Motion Picture and Visual Aids Section, Advertising Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

★Because of the growing concern over the apathetic attitude to religion developed by students as they study science, the Danforth Foundation will sponsor for the third year a seminar workshop on "The Teaching of the Natural Sciences in Relation to Religious Concepts." The sessions will be from July 10 through 23, 1955 on the campus of The Pennsylvania State University.

The director of the seminar will be Dr. W. Conrad Fernelius, professor of chemistry and head of the Department of Chemistry at The Pennsylvania State University.

The cost of the conference, including meals and lodging, for the two weeks will be $95; Danforth scholarships in this amount will be available for twenty-five qualified registrants who apply before May first. A minimum of three years of experience in teaching college courses in the natural sciences or mathematics is required for admission. Registrants who are eligible and meet certain requirements may earn two graduate semester hour credits.

Complete information about the program is available upon request to Dr. W. Conrad Fernelius, The Pennsylvania State University, State College, Pennsylvania.

★An atomic clock which varies only one second in 300 years. The undersea adventures of the scientists at Lamont Geological Observatory. A new source of uranium. These are some of the year's projects of Columbia University Scientists reported in the "Columbia Research News Annual" published this month.

The illustrated 30 page booklet is a compilation of readable reports on some 29 different topics which have appeared during the past year in "Columbia Research News," a newsletter published by the Committee on Science and Engineering Research at Columbia University.

Besides news of important scientific developments, the 1955 "Columbia Research News Annual" presents many sidelights on men who are and have been working at Columbia. The latest "Annual," second to be published, will be mailed to subscribers of the "Research News." Others desiring this booklet should write to Columbia Research News, Columbia University Engineering Center, 4 West 43rd Street, New York 36, N. Y.

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- Evaporation
- Extraction
- Fractional Distillation
- Freezing Point App.
- Grignard Preparations
- Melting Point App.
- Reflux Apparatus
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- Steam Distillation
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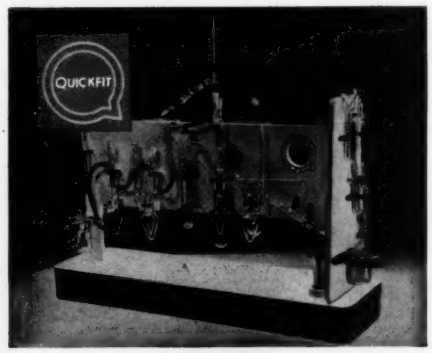

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Over 60 "Quickfit" interchangeable components incorporating "Quickfit" ground glass joints are mounted on both sides of a stand 28" long by 8" wide by 16" high, weighing only 14 pounds. All common organic techniques as listed above can be performed and the complete apparatus is easily portable. The various condensers are connected in series, the water inlet and outlet for the entire unit being located at the foot of the end panel.

#11955 "Quickfit" Semi-Micro Organic Set, complete with glassware, stand, and 3 standard taper thermometers —10 to 110°C, 0–250°C, 0–360°C.....$156.00

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IMMEDIATE DELIVERY ON THESE ITEMS:

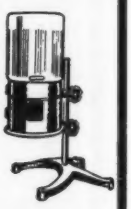
Hi-Speed Centrifuge

Rheostat controlled speeds 1800-5000 rpm suitable for micro and semi-micro analysis, and difficult chemical separations. Holds eight 15 ml straight or tapered tubes. Adapters for ½ to 5 ml tubes. Data sheet 204.

Heaters and Hot Plates

Built specifically for lab service. High quality porcelain refractory tops. Provisions for apparatus set-ups on heaters. Two adjustable heat types: Ful-Kontrol with autotransformer control from 0 to 750 watts and Type RH with built-in rheostat. Catalog 600.

Mag-Mix Stirrers



Magnetically agitate liquids under pressure, in vacuum. Mix viscous liquids. Stir batches of test tubes simultaneously. Rheostat controlled speed ranges. Two electric models, one air model for safe use with flammable liquids. Bulletins 590-R and 595.

Micro-Set Thermo-Regulators

Control temperature within very narrow limits (models as sensitive as ±0.005°F). Operate electrical relay which controls heating elements, etc. Temperature setting may be pre-set or changed. Range spans as wide as —35° to +500°F. Bulletin 647A.

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faster and easier **Na** and **K** determinations

with the **BECKMAN** direct-reading flame photometer

This modern Flame Photometer makes sodium and potassium determinations faster than ever before! Reads directly in milliequivalents without curves or tables. The answer you get is the answer you want.

A unique double control eliminates preliminary fussing. One lever selects the proper potentiometers and filters for either sodium or potassium readings. A pilot light and preset adjustments give instantaneous and efficient flame operation.

To provide long life and trouble-free performance, this Photometer has a stainless steel atomizer separate from the burner. A nebulizing chamber shoots only finely atomized sample to the flame. This reduces internal moisture condensation and clogging deposits, and maintains the flame background noise at a low and steady level.

Natural gas or propane, a source of compressed air, and household current make the Direct-Reading Flame Photometer instantly ready to operate.

The Beckman Direct-Reading Flame Photometer is ideally suited for sodium and potassium studies in: human serum, blood, urine, food products, plant tissues, fertilizers, soils, paper pulp, water, cement.

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